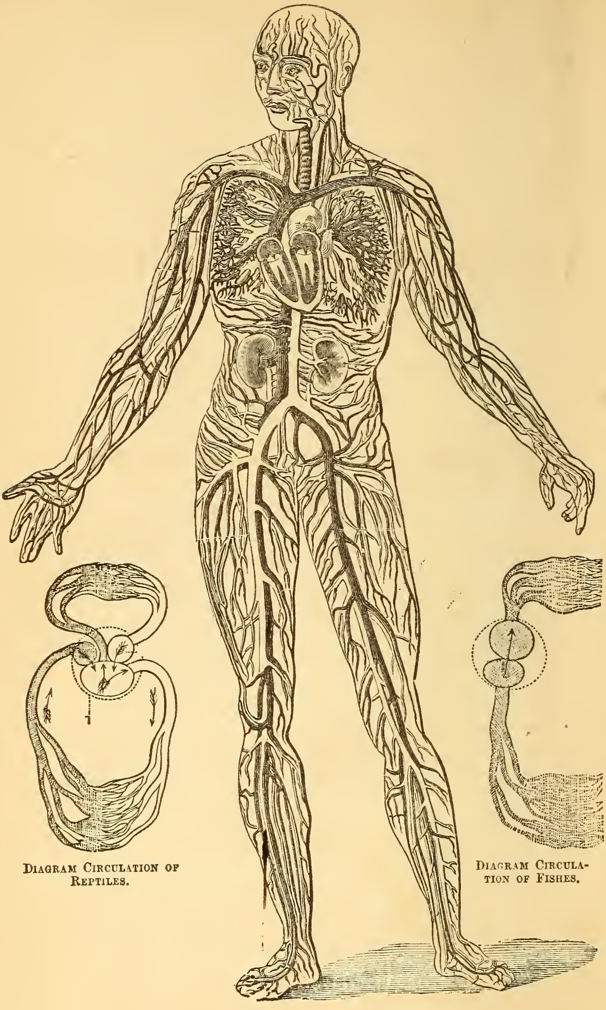

Diagram Circulation of Reptiles.

Diagram Circulation of Fishes.

SECOND BOOK

ON

ANALYTIC

ANATOMY, PHYSIOLOGY AND HYGIENE

HUMAN AND COMPARATIVE.

FOR ACADEMIES, GRAMMAR SCHOOLS AND FAMILIES.

BY CALVIN CUTTER, A.M., M.D.,

AUTHOR OF "NEW ANALYTIC ANATOMY, PHYSIOLOGY AND HYGIENE," AND "OUTLINE ANATOMICAL CHARTS, HUMAN AND COMPARATIVE."

WITH NUMEROUS ILLUSTRATIONS.

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TO THE MEMORY OF

CARRIE ELIZA CUTTER,

WHO ACCOMPANIED THE TWENTY-FIRST REGIMENT OF MASSACHUSETTS VOLUNTEER INFANTRY IN THE "BURNSIDE EXPEDITION" TO NORTH CAROLINA, AND DIED THERE OF CAMP FEVER, CONTRACTED WHILE DISCHARGING THE SELF-SACRIFICING DUTY OF A NURSE,

THIS VOLUME IS DEDICATED BY HER

FATHER AND THE AUTHOR.

TO TEACHERS.

In schools that have the term limited to eight or ten weeks, the Histology, the Chemistry or the Comparative Anatomy may be severally omitted (though with detriment to the pupil), and the remaining sections will be adapted to each other.

The different sections, as far as possible, should be made object lessons, either by the use of the corresponding parts of animals or outline charts, as objects or things make deeper impressions than mere words.

Technical words have not been avoided, for in the investigation of any science the learner will necessarily meet with new terms, and it is best to use those which express the ideas that are peculiar to the study with terseness and the least circumlocution.

PREFACE.

THIS work is intended for classes in academies and grammar-schools. The leading aim has been to so limit its size as to finish it in a term of from ten to fourteen weeks. To accomplish this end, the "New Analytic Anatomy, Physiology and Hygiene, Human and Comparative, by Calvin Cutter, A. M., M. D.," has been followed in arrangement, in illustration and in general scope. Primarily, the work is designed for the class-room, but the brief suggestions relative to Minor Surgery and the Care of the Sick adapt it for general use in families.

The questions given at the close of each chapter may be used at the pleasure of the instructor. The first form educes a thorough *analysis* of each paragraph. The second is *unific*, so that a blended investigation of such paragraphs as agree in structure, function or hygiene may form analytic lessons or reviews. The third form is *topical*, with diagrams and illustrations, to secure a *synthetic* review of each chapter and a summary of the work.

Care has been taken to adapt the work to Outline Anatomical Charts, Human and Comparative, which are as necessary an accompaniment as outline maps in modern Geography.

I am under special obligations to Isaac Walker, A.M., Principal of the High School, Ware, Mass., not only for the Analytic, the Unific and the Synthetic questions of the work, but for the critical examination of each Paragraph, Section, Chapter and Division of the "New Analytic Anatomy, Physiology and Hygiene, Human and Comparative," in his class-room.

Calvin Cutter.

Warren, Mass., July, 1871.

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Anatomy, Physiology and Hygiene.

DIVISION I.

OUTLINE PRINCIPLES.

CHAPTER I.

GENERAL REMARKS.

§ **1.** The Three Kingdoms of Nature Compared.—*Essential Distinctions between the Mineral, Vegetable and Animal Kingdoms. Nature of the Life-force. Vitalized and Non-Vitalized Bodies compared. Plants and Animals compared. Definition of Organs—Of Apparatus—Of Anatomy—Of Physiology—Of Hygiene—Of Histology—Of Chemistry.*

1. "Stones grow; Plants grow and live; Animals grow, live and feel," was the Linnæan distinction between the three great kingdoms of Nature. Though imperfect, it is still suggestive of the boundaries of each division. The *Mineral* kingdom includes all things naturally destitute of life; the *Vegetable* kingdom, all organizations having a *certain type of life*, but no power to feel or to will; the *Animal* kingdom, those possessing a *higher* type of life and the powers of *sensation* and *voluntary* motion.

2. Inorganic or Mineral bodies are made up of atoms combined and arranged according to certain mechanical and chemical laws. Organic or Vegetable and Animal bodies are combinations of like atoms, according to the same laws, controlled by Vitality or the Life-force. Plants have a *vegetable vitality*—animals an *animal vitality*. Of the real charac-

ter of this life-force we know nothing. We are at liberty to examine her products, but the mighty principle upon which they are wrought she holds fast as a secret unrevealable to us with our present limitations.

3. Among the *Distinctions* between ORGANIZED or VITALIZED, and UNORGANIZED or NON-VITALIZED bodies, are the following: 1st, An *Organized* body consists of an assemblage of parts called organs, having a mutual relation to, and dependence upon, each other; these taken together constitute an *individual*, a *being;* therefore the parts when separated are incomplete, as in a divided plant. Not so with the *Unorganized* body: each fragment of a rock possesses all the essential characteristics of the original mass. 2d, *Organized* bodies, being subject to constant waste from vitalized activities, demand nourishment; *Unorganized* bodies, being permanent in their nature, require no food. 3d, *Organized* bodies grow by means of particles of matter conveyed to their interior and there assimilated; *Unorganized* bodies increase in size by simple layers upon the exterior: the former have a limit in size; the latter have no natural limit. 4th, *Organized* bodies have their period of duration: decay and death await every living animal and vegetable; but, from the nature of the *Inorganic* world, we speak of the mountains as everlasting. 5th, *Organized* bodies have their particles arranged in lines generally more or less curved, with varying angles, as in animals and plants; *Unorganized*-bodies have their lines straight, with angles mathematically exact, as in the crystal of common salt. 6th, *Organized* bodies reproduce themselves, each species after its own kind; *Unorganized* bodies have no such power of reproduction.

4. The *Distinctions* between ANIMALS and PLANTS are important. *Animals* take in oxygen and give out carbonic acid gas; *Plants* take in carbonic acid gas and give out oxygen. *Animals* subsist upon the products of the animal and vegetable kingdoms; *Plants*, upon those of the mineral kingdom. *Animals* possess the power of sensation and voluntary motion; *Plants*, neither. These distinctions are obvious and definite

in the higher grades, but in the descending scale we recognize a gradual approach of plants and animals to each other, and likewise to the mineral kingdom; so that in the lower forms of life all perceptible traces of organization disappear, and, like converging radii, the three kingdoms of Nature blend in one common centre.

5. An organized body consists of parts called *Or'gans.* A collection of organs so arranged that their combined actions shall produce a given result is called an *Appara'tus.* The definite, peculiar use of an organ or apparatus is called its *Function: Example.*—The digestive apparatus consists of the organs—teeth, stomach, liver, etc.—whose combined functions result in the digestion of food.

The description of the form and position of these organs is called ANAT'OMY;* the description of their functions, PHYSIOL'OGY;† the examination of the conditions most favorable to their health, HY'GIENE.‡

6. The organs are composed of a variety of structures, called *Tissues,* which are themselves composed of *Cells.* The description of the form, color, constituents and origin of these tissues and cells, or their minute anatomy, is called HISTOL'OGY;§ the science which treats of their ultimate elements is called CHEM'ISTRY.||

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* Gr., *ana,* through, and *tomē,* a cutting.

† Gr., *phusis,* nature, and *logos,* a discourse.

‡ Gr., *hugieînon,* health.

§ Gr., *histos,* a web, and *logos,* a discourse.

|| Ar., *kimia,* hidden art.

2

CHAPTER II.

GENERAL HISTOLOGY.

§ **2.** Cells.—*Unity of Plan exhibited in Plants and Animals. Simple Cells. Adaptation to Different Offices. Modes of Multiplication.*

7. Wherever we find the work of the Infinite, there we find *Unity of Plan.* Whatever the extent of the applications of this plan, whatever its modifications, there is still more or less apparent the distinct *central idea.* Amid the seemingly great diversity of substances in plants and animals, there appears a beautiful and remarkable exhibit of this *Unity.*

8. Protoplasm* is the formal basis of all living bodies. *Animal Pro'to-plasm,* or *Blas-te'ma,*† as it is often called, is an albuminous fluid, generally regarded as identical with the *liquor sanguinis,* or fluid portion of the blood, in which the red corpuscles are suspended. Floating in this protoplasm are numerous minute spheroidal cells, and an infinitude of smaller bodies having the appearance of dots, called granules. From this *organizable fluid* every part of living beings is formed; here is *Unity of Substance.*

9. The simple *Nucleated cell* is the earliest *organic form* of every living thing, and increase of size is but an increase of the number of cells. There are sundry very low animals, each of which is structurally a nucleated cell, a colorless blood-corpuscle, leading an independent life; a step higher come those which are little more than aggregations of similar cells; and at length, as the vital functions become more and more differentiated, appear those with cells variously modified, forming increasingly well-defined and complicated organs, till they seem to reach perfection in man.

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* Gr., *protos,* first, and *plasma,* formed. † Gr., *blastos,* a germ.

10. In the plant-world we find the same plan pursued; under the microscope, the vegetable and the animal cell *appear* essentially the same, but they are by no means identical. In examining the *nucle'oli* of animal cells, *little circular bodies* dart across the field of view. These seem to possess the power of voluntary movement; and, had we the requisite refinement of sight, we should doubtless be able to classify even these minute bodies as accurately as we now do the fully-developed animal. In the vegetable cell these are never seen. It appears, then, that the lowest and the highest organism—the fungus and man—have, in their earliest development, a *unity of form* of which the type is the simple cell.

Fig. 1.

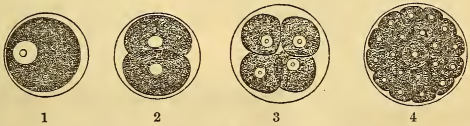

Fig. 1. An Ideal Cell.—1, Cell, with its wall, protoplasm, nucleus and its nucleolus. 2, The same divided into two. 3, The same divided into four cells. 4, The same divided into many cells. The dark portion, the protoplasm; the white spot, the nucleus; the inner small circle, the nucleolus. Magnified.

11. A Simple Cell consists of a delicate sac containing protoplasm, in which is another very minute sac, called the *nu'cleus*, which contains yet another sac—the *nucleolus* or little nucleus. Very minute particles or granules are also seen. A good example of a simple animal cell on a large scale is an egg: the lining of the shell is the cell-wall or sac; the white is the contained *protoplasm;* the yolk is the *nucleus;* and its germ-spot is the *nucleolus.* (Figs. 1, 2.)

12. Cells in the course of their development are subject to numberless modifications—the animal cell, to subserve various purposes in the animal economy; the vegetable cell, in the vegetable economy. As if under the immediate control of intelligence, they select each its own appropriate substance, rejecting all else. One set of cells has for its office the production of motion; another set is for the purpose of secre-

tion; another, for assimilation; another, for absorption; still another, for reproduction; and so on, through all the dissimilar offices of the animal economy.

13. Cells multiply in three ways: 1st, A cell may elongate, contracting in the middle like an hour-glass or dumb-bell, by the infolding of the cell-wall, till a complete division is made and two cells are formed, each with its own share of the original nucleus; the new cells divide in a similar manner, and like divisions are repeated indefinitely; 2d, Another form of multiplication is by the division of the nucleus *within the cell;* each part appropriates a portion of the fluid, and at length vesicles are formed, the old cell-wall breaks, and the vesicles develop into perfect cells; and 3d, Cells are sometimes developed *de novo* from the protoplasm, which contains nuclei and granules. (Figs. 1, 2, 3.)

Fig. 2.

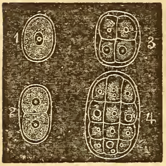

Fig. 3.

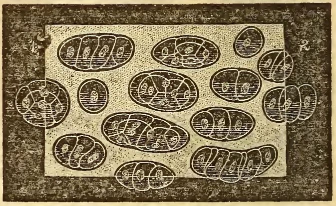

Fig. 2. Process of Multiplication of Cells.—1, Simple cartilage cell from the embryo. 2, Increase of cartilage cells by division of the primary cell. 3, 4, Groups of cartilage cells, from an adult articular cartilage. Magnified.

Fig. 3 exhibits Groups of Cartilage Cells imbedded in a homogeneous matrice. 1, Toward the exterior. 2. Toward the interior surface. Highly magnified.

14. Cells have their period of growth, of perfection and of decay. While the vital force directs and controls the chemical and mechanical agencies, they tend to preserve and build up the system; but when the vital powers yield, they tend to its decay, and, "as if they were the grave-diggers of Nature, fulfill the old motto—'Earth to earth and dust to dust.'"

§ **3.** Primary Tissues.—*Fibrous Tissue—Areolar—Cartilaginous—Adipose—Muscular—Sclerous—Tubular—Nervous.*

15. By the various aggregations and transformations of cells the different tissues of the body are formed, and their individual characters depend upon the peculiar selecting power of these cells.

16. The Primary Tissues are reducible to the following: the *Fi'brous*, the *Are'olar* and the *Cartilag'inous*, which, collectively, form the *Connect'ive* tissues; and the *Ad'ipose*, the *Musc'ular*, the *Scle'rous*, the *Tu'bular* and the *Ner'vous* tissues.

Fig. 4.

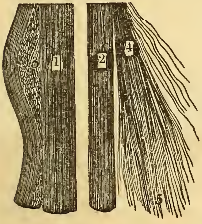

Fig. 5.

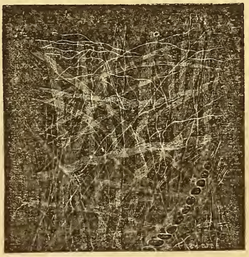

Fig. 4. Fibrous Tissue.—1, Portion of tendon, exhibiting its composition of prismatic bundles of fibrous tissue, the filaments all parallel to one another. 2, A few bundles drawn from the others, exhibiting their union by delicate crossing filaments of connective tissue. 3, One of the varieties of fibrous tissue. 4, A single bundle, more highly magnified, with a portion (5) of the filaments fretted out.

Fig. 5. Portion of Connective Tissue, from the axilla, exhibiting its composition of bundles and filaments of fibrous tissue crossing in every direction. The rounded bodies represent a single row and a portion of small groups of fat cells. Magnified.

17. The Fibrous form of connective tissue is composed of minute filaments arranged in parallel and somewhat wavy bundles, marked with faint cross-waves. It is strong, unyielding and glistening. The fibrous tissue has two distinct forms—the *White Fibrous* and the *Yellow Fibrous.*

18. The White Fibrous tissue is formed of white, glistening, inelastic bands, having longitudinal creasings, but not admitting of separation into filaments of determinate size. This tissue, by long boiling, is entirely resolved into *Gel'atine.*

The white fibrous tissue is found under three forms: *Mem'-brane,** *Lig'ament*† and *Ten'don.*‡

19. The Yellow Fibrous tissue is composed of yellow elastic bands separable into their component filaments. It is called the *Elas'tic* tissue, elasticity being its chief characteristic. It does not gelatinize by boiling. It is found in the middle coat of the arteries, in the vocal cords, between the vertebræ, and in many other places where elasticity is needed. (Figs. 4, 5.)

Observation.—In rheumatism the connective white fibrous tissue is the part chiefly affected; hence, the large joints and the loins, where this tissue is most abundant, suffer most. Where there is predisposition to rheumatism, the tendency to it may be lessened and attacks relieved by increasing the amount of clothing over the part affected.

20. The Areolar form of connective tissue consists of bands of the fibrous, both of the white and yellow, which interweave in every direction, leaving open spaces between, called cells; hence this tissue is sometimes called *Cel'lular.* These spaces communicate through the body, and contain a fluid resembling the serum of the blood. Although the connective areolar tissue enters into the composition of all organs, it never loses its individuality. In the nerves and muscles it shares neither the sensibility of the one nor the contractility of the other. (Figs. 5, 6.)

Observation.—The swelling of the feet so often seen in feeble persons shows the peculiarity of this tissue, which allows the fluid to pass from part to part and accumulate in the lowest portion of the body, while a recumbent position restores the original shape. Great excess of the fluid produces general dropsy. The free communication between all parts of this tissue is still more remarkable in regard to air. Sometimes, when an accidental opening has been made from the air-cells of the lungs into the adjacent tissue, the air in respiration penetrates every part of the surrounding tissue, and even of the entire body, till inflation endangers life from suffocation. Butchers often avail themselves of this fact, inflating their meat to give it a fat appearance.

21. Cartilaginous tissue consists of a solid *mat'rice,* ap-

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* Lat., *membrana,* a web. † Lat., *ligo,* to tie or bind.
‡ Gr., *teinō,* to stretch.

parently homogeneous in structure, resembling ground glass. In this are imbedded nucleated cells, sometimes arranged simply, but usually in groups. It has no perceptible nerves nor blood-vessels. Cartilage is elastic and flexible, but inextensible—qualities admirably essential to its use in the formation of the joints and in giving to other organs form and strength without too much rigidity. This tissue constitutes the articular cartilages, the cartilage of the ribs, of the larynx (except the epiglottis), of the trachea and its divisions, and of the nose. The bones usually originate in cartilage, which disappears as bony matter is deposited; such cartilage is called *temporary*, while that which continues till later years is called *permanent*. (Fig. 3.)

Fig. 6.

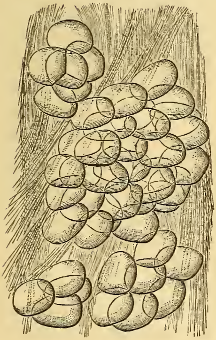

Fig. 7.

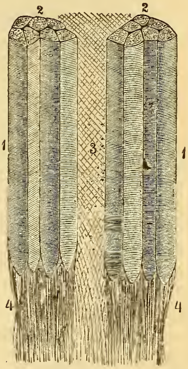

Fig. 6. Adipose Tissue, with groups of fat vescicles contained in the meshes of connective tissue.

Fig. 7. Muscular Tissue.—1, Two portions of a muscular fasciculus. 2, Cut extremities of the fibres, showing their prismatic form. 3, Delicate sheath, composed of obliquely-crossing filaments of fibrous tissue. 4, The fibres of the commencing tendons. Partly a diagram.

22. Adipose tissue has the peculiarity of not being *essential* to the constitution of any organ. It is composed of delicate aggregated cells of nearly spheroidal form, containing a

substance called fat. It is found in the interspaces of areolar tissue beneath the skin, and also around the heart and kidneys, while none is ever found within the skull, the lungs and the eyelids, where its presence would interfere with their several functions. Fat accumulates more readily than other matter, and is the earliest removed in disease. It is a storehouse of nutriment always ready for use and a non-conductor of heat; it also gives roundness and beauty to the form.

Fig. 8.

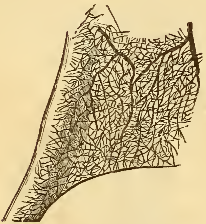

Fig. 9.

Fig. 8 (*Wagner*). A Piece of the Web of a Frog's Foot, showing the fine capillary network connecting the termination of the arteries with the commencement of the veins.

Fig. 9 (*Allen Thomson*). Minute Piece of the Margin of the Frog's Web, showing the ultimate capillaries, connecting the end of a small artery with the beginning of a minute vein. The oval blood-corpuscles, with nuclei, are seen in these vessels, and the arrows entering and passing out of the artery and vein indicate the course of the blood-current. Magnified about thirty diameters.

23. Muscular tissue is composed of fibres, which are themselves composed of minute fibres, called *fi'brillæ* or filaments. This tissue has for its peculiar characteristic *contractility*, and is the instrument upon which the sensible motions of the body depend. It is a good conductor of electricity, and very sensitive to that agent. It has within itself constant electrical currents, called, collectively, the *muscular current*. (Fig. 7.)

24. Sclerous tissue is found in the bones and teeth. Its composition and arrangement vary at different periods of life.

25. Tubular tissue consists of a network of minute tubes,

called *cap'illary** vessels. These vessels connect the terminal extremities of the arteries with the commencement of the veins, but are otherwise closed, and never communicate except by imbibition with the structures through which they pass. Their walls are composed of exceedingly thin, transparent, structureless membrane containing scattered nuclei. They vary in size, being largest in the bones and smallest in the brain and in the lungs. This tissue is found in all parts of the body, excepting the substance of the teeth, the cartilage of the joints, the transparent part of the eye, the *epithe'lial* tissue, the hair and the nails. (Figs. 8, 9.)

26. The NERVOUS tissue is distinguished from all other tissues by its *sensibility.* Like the muscular tissue, it has constant electrical currents. It forms the essential substance of the brain, spinal cord and nerves. This tissue contains three distinct microscopical elements — *Nerve-Cells* or *Ganglionic Corpuscles; Gray* or *Gelatinous* fibres; and *White* or *Tubular* fibres.

FIG. 10.

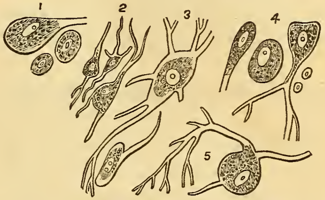

FIG. 10 (*Kolliker and Hannover*). 1, Nucleated cells from a sympathetic ganglion. 2, Branched or stellate cells from the gray substance of the spinal cord. 3, Branched cells from the medulla oblongata. 4, Simple and branched cells from the convolutions of the brain. 5, A large cell from the gray substance of the brain. Magnified one hundred diameters.

27. The GANGLIONIC CORPUSCLES are cell-bodies containing pulpy matter, with one or more nuclei surrounding colored granules. These cells vary in shape, being roundish, pear-shaped or branched in a caudate or stellate manner, these offsets being continuous with the cell-wall and its contents, and often entering another cell and connecting the two. These nerve-cells are found in the brain, spinal cord

* Lat., *capillus*, a hair.

and ganglia, and at the extremities of the nerves of sight and hearing. (Fig. 10.)

28. The GRAY or GELATINOUS fibres are soft and granular, with no distinct medullary sheath. They contain many dark nuclei, and are most abundant in the sympathetic ganglia and its branches.

29. The WHITE or TUBULAR fibres are microscopic tubes. The walls are structureless membrane enclosing a layer of medullated matter resembling fluid fat, which acts as a sheath; within this is a firmer part or core, called the *band-axis* or axis cylinder: this is albuminous.

The gray substance is most abundant in the outer part of the brain, and the white in the inner; but the two intermix more or less in every part of the nervous system.

§ 4. MEMBRANES.—*Basement Membrane. Epithelium. Serous Membrane. Synovial Membrane.*

30. BASEMENT MEMBRANE is an exceedingly thin, delicate, structureless layer of protoplasm or blastema, resembling, under the microscope, a film of transparent gelatine. Upon it, in various parts of the body, are imbedded minute epithelial cells. The membrane formed by these cells is called *epithe'lium.** The relation of this structureless membrane to the epithelium gives it the name of *Basement Membrane.*

FIG. 11.

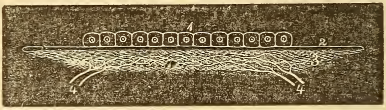

FIG. 11. DIAGRAM EXHIBITING THE RELATIVE POSITION OF THE COMMON ANATOMICAL ELEMENTS OF SEROUS AND MUCOUS MEMBRANES, THE GLANDS, THE LUNGS AND THE SKIN. —1, Epithelium, secreting cells or epidermis, composed of nucleated cells. 2, Basement layer. 3, Fibrous layer, in which the arteries and veins (4) terminate in a capillary network. Magnified.

31. From difference in form and other peculiarities, the

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* Gr., *epi*, upon, and *thēlē*, a nipple.

EPITHELIUM is divided into several varieties—as the *Squamous* Epithelium, consisting of several layers of thin scales, which are flattened cells having a nucleus and a few scattered granules, as in the mucous membrane of the mouth; the *Pavement* Epithelium, consisting of from one to four layers of nucleated cells, six-sided and regularly arranged like the blocks of a pavement (whence the name), as in the serous membranes; the *Columnar* Epithelium, consisting of a single layer of six-sided columnar cells, with a conical pro-

FIG. 12.

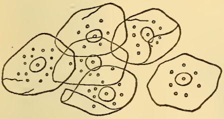

FIG. 13.

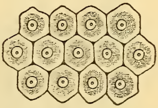

FIG. 12. SQUAMOUS EPITHELIUM, consisting of nucleated cells transformed into broad scales, from the mucous membrane of the mouth. Highly magnified.

FIG. 13. PAVEMENT EPITHELIUM, from a serous membrane, highly magnified, and seen to consist of flat, six-sided nucleated cells.

longation terminating in a progeny of developing cells, as in the mucous membrane of the stomach and intestines; the *Ciliated* Epithelium, having cells possessing at their free extremity fine filamentary processes of the cell-wall resembling the eye-lashes (whence the name). During life these cilia are endowed with a power of moving rapidly backward and forward in a wave-like manner, reminding one of the movement of a field of grain swept by a gentle breeze. Currents are thus produced in liquids, conveying them from one part to another. This kind of epithelium is found on the mucous membrane of the upper part of the nose and pharynx, the Eustachian tube and all the respiratory organs. (Figs. 12, 13, 14, 15.)

32. Beneath the basement membrane and in contact with it is a very dense and vascular layer of areolar and elastic tissue. This triple arrangement of epithelium, basement membrane and fibro-areolar tissue constitutes the serous, the synovial and the mucous membranes, the skin, the ducts of

all glands, and the inner coat of the blood-vessels and the lymphatics. (Fig. 11.)

33. The SEROUS MEMBRANE is that portion which lines the walls of certain closed cavities or sacs. It is smooth, shining and moistened by a fluid called *se'rum*, which the membrane secretes; as the *pleu'ra, peritone'um, pericar'dium, arach'noid*, etc. (Fig. 16.)

FIG. 14.

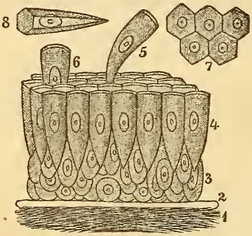

FIG. 15.

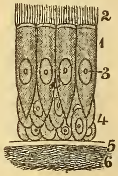

FIG. 14. DIAGRAM OF A VERTICAL SECTION OF THE MUCOUS MEMBRANE OF THE SMALL INTESTINES. Highly magnified.—1, Fibrous layer, in which the blood-vessels are distributed. 2, Basement membrane. 3, Young nucleated cells. 4, Layer of columnar cells. 5, 6, Cells in the act of being shed or thrown off. 7, Free ends of the columnar cells, exhibiting their six-sided form. 8, A single columnar cell, exhibiting its actual form at all parts.

FIG. 15. DIAGRAM OF A VERTICAL SECTION OF THE BRONCHIAL MUCOUS MEMBRANE.—1, Columnar ciliated epithelial cells. 2, Cilia. 3, Nuclei. 4, Young cells. 5, Basement membrane. 6, Fibrous layer.

34. The SYNOVIAL MEMBRANE resembles the serous very closely as regards structure and the closed sacs. It also secretes a fluid called *syno'via*, which is more viscid than that of the serous membrane. It has fringe-like processes hanging loosely in the joints having large epithelial cells, which probably secrete the synovial fluid. This membrane covers the cartilages, and lines the ligaments which enter into the composition of the joints.

Observation.—When the synovial membrane is ruptured, the synovia escapes into the surrounding areolar tissue, and what is popularly known as the "weeping sinew" is formed. Similar tumors in the joints of lower animals are called "windgalls."

35. There are two Mucous Membranes—the *Gastro-Pulmonary* and the *Urinary*. These do not form closed sacs, like the serous and synovial membranes, but both open to the surface. The mucous membranes secrete a viscid fluid, called *mu'cus*, and in their glandular recesses are formed various secretions, as *sali'va*, *bile*, *tears*, etc. These membranes vary in different parts both in thickness and appearance. In the nasal and air passages the membrane is smooth, ridgy in the stomach, papillous in the tongue and villous in the intestines.

Fig. 16.

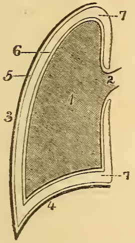

Fig. 17.

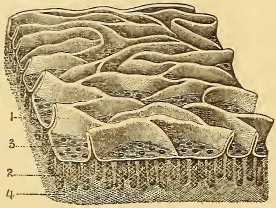

Fig. 16. Diagram exhibiting the Relation of a Serous Membrane (*the pleura*) to the Organ it Invests and the Cavity it Lines.—1, Lung. 2, Root of the lung, which is the only attached portion of the organ. 3, Side of the thorax. 4. Diaphragm. 5, Parietal pleura. 6, Pulmonary or reflected pleura. 7, Cavity of the pleura.

Fig. 17. Mucous Membrane from the Jejunum.—1, Villi resembling valvulæ conniventes (folds of lining mucous membrane) in miniature. 2, Tubular glands: their orifices. 3, Opening on the free surface of the mucous membrane. 4, Fibrous tissue. Magnified.

36. The Gastro-Pulmonary Mucous membrane commences at the mouth, enters the nostrils, passes between the eyelids, dips into the deep parts of the ear, lines the trachea and the air-tubes of the lungs, and the alimentary canal from one extremity to the other.

37. The Urinary Mucous membrane lines the ducts connecting the kidneys and the bladder, of which it forms the interior coat; also the passages to the skin, which integument is continuous with the mucous membranes.

CHAPTER III.

GENERAL CHEMISTRY.

§ **5.** SOLIDS AND FLUIDS.—*Proximate Constituents—Inorganic—Organic—Nitrogenous—Non-Nitrogenous. Ultimate Chemical Elements.*

38. THE human body is composed of solids and fluids, reducible, by chemical analysis, to the same constituents and elements. In different periods of life the proportion of fluids and solids varies; the former being more abundant in youth than in old age. This is one reason why the limbs in childhood are soft and smooth, but in later years hard and wrinkled.

39. If the tissues of the body are subjected to chemical analysis, they yield about ninety substances, called *Proximate Constituents,* these being the first chemical compounds into which the tissues resolve themselves. In living beings vitality is, as it were, "the architect who plans the building and sees that the requisite materials are procured by the chemical processes and worked up according to his will." Hereupon arises many new substances which cannot be artificially imitated; these are called *Organic proximate constituents.* Those substances found in the inorganic kingdom also, and capable of artificial imitation, are called *Inorganic proximate constituents.*

40. Of the INORGANIC PROXIMATE CONSTITUENTS, water is the most abundant: it exists in all the tissues; next to this, in relative quantities, are *Phosphates* of *Lime,* of *Magne'sia,* of *Soda* and of *Potas'sa; Carbonates* of *Lime,* of *Soda* and of *Potassa; Chloride* of *Sodium* (common Salt) and of *Potassium;* and *Fluoride* of *Cal'cium.* Some compounds contain *Iron, Sil'ica, Manganese',* and perhaps some accidental substances, as *Lead, Copper* and *Alu'minum. Ammo'nia,* in

combination, is found in the urine. *Ox'ygen, Ni'trogen* and *Carbonic Acid* gas exist in a free state.

41. The ORGANIC PROXIMATE CONSTITUENTS are of two classes. One class contains the chemical element *Azote'* * or *nitrogen;* hence its compounds are called *az'otized* or *nitrog'-enous;* the other has no azote, and its compounds are named *non-azotized* or *non-nitrogenous.*

42. The NITROGENOUS class contains *Albu'men*† and its allied substances, called Albuminoids. Some of the most important are—*Albu'minose, Fi'brin, Mus'culin, Glob'ulin, Hæm'atin, Ca'sein, Cartila'gin, Sal'ivin, Pep'sin, Pancrea'tin, Mu'cin, Neu'rin, Ker'atin, Elas'tin, Mela'nin* and *Biliverd'in;* also some acids, as the *Cer'ebric, Chol'ic* and *U'ric.*

43. ALBUMEN and the albuminoids, together with fatty matter (non-nitrogenous), are the great nutritive substances of the animal economy. Albumen is well known in the white of an egg, whence its name. It is found in the substance of the brain and nerves; in the fluid part of the blood; in the moisture that pervades the muscles and other tissues; in the lymph and chyle; and in the mucous, serous and synovial secretions. It coagulates by the action of heat and alcohol, and is dissolved by weak acids and alkalies.

44. ALBUMINOSE is found in the chyle and blood in a liquid condition, and is the result of the digestion of albuminous, fibrinous, musculinous and caseous matter of food; unlike albumen, it is not coagulated by heat.

45. FIBRIN is a soft, white, stringy substance, obtained from freshly-drawn blood by whipping it with fine sticks or wires. It coagulates spontaneously, assuming the form of minute threads or *fi'brils,* whence its name. Fibrin is also found in the chyle, lymph and serous secretions. It is precipitated and hardened by alcohol, and redissolved by weak acid.

46. MUSCULIN is a peculiar form of fibrin that exists in the muscles or flesh. Its characteristic property is *contractility.* Boiling hardens it, while weak acids render it more soluble.

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* Gr., *a,* not, and *zoē,* life.

† Lat., *albus,* white.

47. Globulin and Hæmatin form the contents of the red globules of the blood. Hæmatin contains about seven per cent. of iron; but the color of the blood is now supposed not to depend on the iron, but a peculiar substance named *cru'orin.*

48. Casein resembles albumen in its general properties, but, unlike albumen, when in solution it is not coagulated by heat, but by acids. It exists in solution in milk with *lac'tin* (milk sugar) and salts. It forms the curd in soured milk, the casein being coagulated by the *lactic acid* formed from decomposed lactin.

49. Cartilagin is the principal constituent of the connective tissues, as the so-called bone cartilage, true cartilage, ligaments, tendons, fibrous membranes, dermis and the areolar tissue. The basis of bone cartilage is *os'teine,* with which are blended salts of lime. The basis of true cartilage is called *chon'drigen.* Unlike albumen, cartilagin is insoluble in water and does not coagulate by heat, but is liquified by boiling and changed into *gel'atin* or glue.

50. Salivin is found in the saliva. It has the peculiar property of changing starch into a kind of gum called *dex'trine,* the dextrine into *glu'cose* or grape sugar, and this into *lactic acid.*

51. Pepsin is a remarkable and potent substance secreted by the glands of the mucous membrane of the stomach. This secretion is a peculiar principle of the gastric juice, and, when slightly acidulated, has the property of quickly dissolving coagulated albumen, blood, meats, fish, cheese and many other substances.

52. Pancreatin is the active principle of the secretion of the pancreas. It has three distinct actions—1st, on starch; 2d, on fat; and 3d, on albuminous matter.

53. Mucin is a substance found in the different varieties of mucus, imparting to them their viscid character. It is usually mixed with other fluids.

54. Neurin is also an albuminoid substance connected with the brain and nerves, upon which the peculiar characteristics of the nervous system are supposed to depend.

55. Keratin is the peculiar albuminoid principle giving the horn-like character to the hair, nails and cuticle.

56. Elastin is the substance peculiar to the elastic tissue. It is insoluble in all common fluids.

57. Melanin is a blackish-brown coloring matter found in the choroid coat and the iris of the eye, in the hair and in the epidermis. It is most abundant in the black and brown races, but it also exists in the yellow and white races.

58. Biliverdin is the coloring matter of the bile. It is yellow in transmitted light and greenish in reflected light. On exposure to the air in its natural fluid condition, it absorbs oxygen and assumes a bright grass-green color.

59. Besides the before-mentioned constituents, none of which are acid but mucin, there are several acids, among which may be named the *Cerebric* acid found in the gray substance of the brain; *Cholic* acid in the bile; and *Uric* acid in the urine.

60. The groups of non-nitrogenized or non-azotized substances are—the fats, sugars and starch. The fats are most abundant. These are insoluble in water, but are dissolved by heat, alcohol and ether. They are found in the brain, muscles, blood and chyle.

61. The Fats of the human body are composed mostly of *o'lein* (liquid fat), and *ste'arin* and *mar'garin* (solid fats), margarin being most abundant, and stearin least. The fats are derived from the fatty components of food, and also from transformed saccharine compounds. When boiled with an alkali, as in the manufacture of soap, they decompose into fatty acids, margaric, stearic and oleic acids, and a sweet, viscid substance called *glyc'erine.*

62. Sugars are of different kinds, as *Glu'cose* (grape sugar), in the blood and chyle; Liver sugar, in the liver; *Lac'tin* (milk sugar), in milk; *In'osit* (muscle sugar), in muscles. Lactin, in contact with azotized matter, or a *ferment*, easily decomposes, forming lactic acid. All these saccharine and acid substances are soluble in both water and alcohol.

3*

63. The ULTIMATE CHEMICAL ELEMENTS enter into the composition of the body in about the following percentage proportions:

GASES.	Oxygen	72.
	Hydrogen	9.1
	Nitrogen	2.5
	Chlorine	.085
	Fluorine	.08
SOLIDS.	Carbon	13.5
	Phosphorus	1.15
	Calcium	1.3
	Sulphur	.1476
	Sodium	.1
	Potassium	.026
	Iron	.01
	Magnesium	.0012
	Silicon	.0002
		100.0000

64. The greater part of the oxygen and hydrogen exists in a state of water, but the dried residue still contains some gaseous as well as solid elements.

65. CARBON is the most abundant element. In the inevitable decomposition of the body, while its hydrogen and nitrogen, with part of its carbon and oxygen, are restored to the inorganic world in the shape of *water*, *carbonic acid* and *ammonia*, the rest of its carbon and oxygen, its chlorine and fluorine, its phosphorus and sulphur, and its metallic bases, calcium, sodium, potassium, magnesium and iron, with a trace of silicon and manganese, revert to the condition of *inorganic salts* and *earths*—viz., carbonates, sulphates and phosphates, chlorides and fluorides of the above-named saline and earthy bases.

ANALYTIC EXAMINATION.

CHAPTER I.—GENERAL REMARKS.

§ **1.** *The Three Kingdoms of Nature Compared.*—1. State the Linnæan distinctions of the three kingdoms of Nature. Name the three kingdoms, and define each. 2. Of what are Organic and Inorganic bodies combinations? What is said respecting Life-force? 3. Give the distinguishing features of Organized and Unorganized matter. 4. State the distinctions between animals and plants. What is said of these distinctions in the lower forms of life? 5. Define Organ, Apparatus and Function. What is Anatomy? Physiology? Hygiene? 6. Of what are organs composed? Define Histology and Chemistry.

CHAPTER II.—GENERAL HISTOLOGY.

§ **2.** *Cells.*—7. Where do you find Unity of Plan? 8. Define Protoplasm. What is Animal Protoplasm? 9. What is said of nucleated cells? Of the modifications of these cells? 10. Distinguish between animal and vegetable cells. Of what is the simple cell the type? 11. Of what does a simple cell consist? Give an illustration. 12. To what modifications are cells subject? 13. In what ways do cells multiply? 14. What is said of the growth, perfection and decay of cells?

§ **3.** *Primary Tissues.*—15. How are the different tissues of the body formed? Upon what do their characters depend? 16. To what are the Primary Tissues reducible? 17. Of what is the Fibrous form composed? State its nature and forms. 18. Give the composition and forms of the White Fibrous tissue. What is Gelatin? 19. Describe the Yellow Fibrous tissue. Why called Elastic? Does it gelatinize by boiling? Where found? Observation. 20. Of what does the Areolar form consist? What is said of its cellular structure? What of its individuality? Observation. 21. Describe the Cartilaginous tissue. Mention the properties of Cartilage. Where is this tissue found? What is the relation of cartilage to bone? 22. What peculiarity has the Adipose tissue? Of what composed? Where found? Its use? 23. Give the composition of Muscular tissue. What is its characteristic? What of its electrical nature? 24. Describe the Sclerous tissue. 25. Describe the Tubular tissue. What is the office of the capillary vessels? Of what are their walls composed? Where is this tissue found? 26. How is the Nervous tissue distinguished? Where found? In what respect like the Muscular tissue? Mention its elements. 27. Describe the Ganglionic Corpuscles. 28. What is said of the Gray fibres? Where found? 29. Speak of the White fibres. Where are the gray and white substances found?

§ **4.** *Membranes.*—30. What is the Basement membrane? What is the Epithelium? Why these membranes so called? 31. Name and describe the varieties of the Epithelium. Of what power the Cilia? Where is the Ciliated Epithelium found? 32. What is beneath the basement membrane? What are constituted by the epithelium, basement membrane and fibro-areolar tissue? 33. Where is the Serous membrane found? Its qualities? 34. What is said of the Synovial membrane? Observation. 35. Describe the Mucous membranes. 36. Where is the Gastro-Pulmonary Mucous membrane found? 37. Where the Urinary? Observation.

CHAPTER III.—GENERAL CHEMISTRY.

§ **5.** *Solids and Fluids.*—38. Of what is the human body composed? What is said of the proportion of solids and fluids? 39. What are the Proximate Constituents? Define Organic and Inorganic Proximate Constituents. 40. Name the Inorganic Proximate Constituents. 41. Give the classes of Organic Proximate Constituents. 42. What are contained in the Nitrogenous class? Name the most important. 43. What is the office of Albumen in the animal economy? Give the derivation of its name. Where found? What peculiarity has it? 44. Describe Albuminose. 45. What is Fibrin? Where found? What is the influence of alcohol upon it? 46. Describe Musculin. How

hardened? 47. Where are Globulin and Hæmatin found? 48. Give the properties of Casein. Where does it exist? 49. Define Cartilagin. What is Osteine? Chondrigen? 50. Define and give the property of Salivin. 51. Describe Pepsin, and state its property. 52. What is Pancreatin? State its actions. 53. Describe Mucin. 54. What is Neurin? 55. Define Keratin. 56. To what is Elastin peculiar? 57. Where is Melanin found? 58. Of what use Biliverdin? Color? 59. Name the acids of the nitrogenous class. 60. Mention the non-nitrogenous groups. 61. Of what are the fats composed? From what derived? What is Glycerine? 62. Mention the different kinds of sugars. 63. Name the ultimate chemical elements, with their percentage proportions. 64. In what condition are oxygen and hydrogen? What is said of carbon? 65. What becomes of the chemical elements in decomposition?

UNIFIC REVIEW.

[Compare 8 with 102.]

What is Protoplasm?

[Compare 10–14 with 102, 103, 220, 314, 317, 319, 347, 357, 410, 415, 417, 478 and 485–488.]

Describe nucleated cells, and tell where found. In the lining membrane of what organs do you find the epithelium? Where do you find ciliated epithelium?

[Compare 17–21 with 105–108, 163, 289, 313–317, 319, 355, 356, 415 and 416.]

Name the connective tissues. Mention some distinguishing features of each. Where do you find the white fibrous tissues? Where the yellow fibrous? Where is cartilage found?

[Compare 24 with 103 and 104.]

What tissue is found in bone? Give the mode of bone-formation.

[Compare 23 with 159–162, 223–226 and 316–319.]

What is the structure of muscular tissue? Where found? What is its relation to the cellular?

[Compare 25 with 318 and 411–414.]

Where do you find the tubular tissue?

[Compare 26–29 with 409–414.]

Tell what you can about the nervous tissue.

[Compare 30–32 with 220, 221, 223–226, 229, 314, 317, 319, 346, 356, 357, 415 and 416.]

Where is the Basement membrane found?

[Compare 33 with 229, 313, 358 and 415.]

Where do you find the Serous membrane?

[Compare 34 with 107 and 163.]

What is the office of the Synovial membrane?

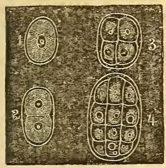
[Compare 35–37 with 220, 221, 223–226, 354–357 and 478–480.]

Name the mucous membranes. The mucous membrane lines what organs? Point out the difference between mucous and serous membranes. With what is the mucous membrane continuous?

[131.]

What is said of the tissues, cells and chemical composition of all animals?

For description of the diagrams, see corresponding figures in the text.



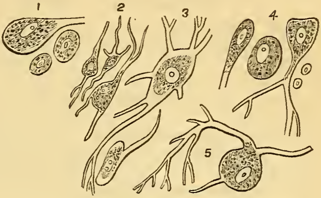
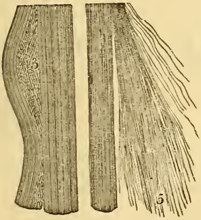


FIG. 2. PROCESS OF MULTIPLICATION OF CELLS.
FIG. 10. NUCLEATED CELLS FROM NERVOUS TISSUE.



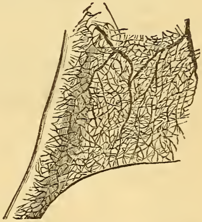
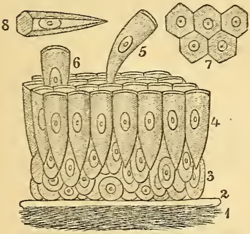


FIG. 4. FIBROUS TISSUE.
FIG. 8. CAPILLARY NETWORK REPRESENTING TUBULAR TISSUE.



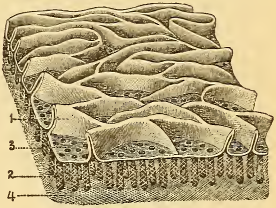


FIG. 14. DIAGRAM OF A VERTICAL SECTION OF THE MUCOUS MEMBRANE.
FIG. 17 REPRESENTS MUCOUS MEMBRANE FROM THE JEJUNUM.

SYNTHETIC TOPICAL REVIEW.

Essential distinctions between mineral, vegetable and animal kingdoms, Nature of life-force, Vitalized and non-vitalized bodies compared, Animals and plants compared, These distinctions in higher and lower forms, Organ, apparatus and functions, Anatomy, Physiology and Hygiene, Structure of organs, Histology and Chemistry.	§ 1. *Three Kingdoms compared.*	CHAP. I. *General Remarks.*	Division I. *Outline Principles.*
Unity of plan in animals and plants, Protoplasm, Nucleated cell, Simple cell, Adaptation to different offices, Modes of multiplication of cells, Growth, perfection and decay.	§ 2. *Cells.*	CHAP. II. *General Histology.*	
Primary tissues, Fibrous tissue, Areolar, Cartilaginous, Adipose, Muscular, Sclerous, Tubular, Nervous.	§ 3. *Primary Tissues.*		
Basement membrane, Epithelium, Serous membrane, Synovial " Mucous membranes.	§ 4. *Membranes.*		
Solids and fluids, Proximate constituents, Inorganic " Organic " Nitrogenous " Non-nitrogenous " Ultimate chemical elements.	§ 5. *Solids and Fluids.*	CHAP. III. *General Chemistry.*	

State the General Remarks, the General Histology and the General Chemistry of the human system.

DIVISION II.

MOTORY APPARATUS.

66. In all the movements connected with the merriments of childhood, with the ceaseless industry of the toiling millions, with the hymning of the praises of the great I Am—in a word, in every movement of the body—certain organs are brought into action, which, taken collectively, constitute the Motory Apparatus. The organs of this apparatus are the *Bones* and *Joints*, the *Muscles* and *Motor Nerves.*

CHAPTER IV.

THE BONES.

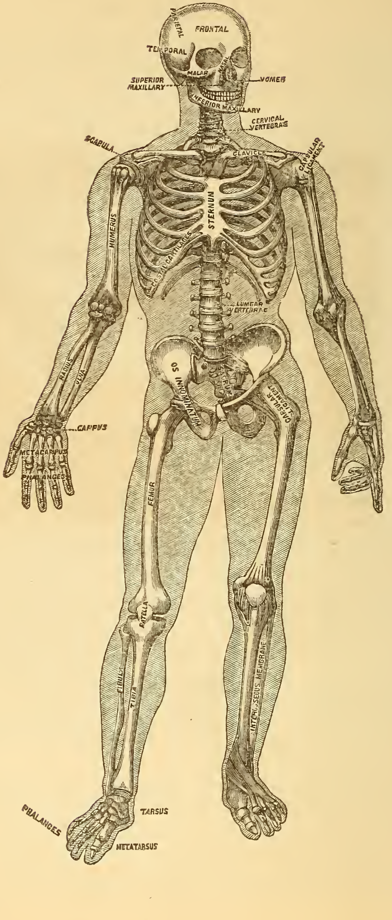
§ **6.** Anatomy of the Bones.—*The Skeleton and its Uses. Number and Classification of the Bones. Bones of the Head—Of the Trunk—Of the Upper Extremities—Of the Lower Extremities. The Joints—Definition and Classification. Immovable Joints—Mixed—Movable.*

67. The Internal Framework of the human body consists of Bones, which, united by strong ligaments, constitute the *Skeleton.* These bones number two hundred and eight, besides the teeth. For convenience they are classed as the bones of the *Head,* the *Trunk* and the *Extremities.*

68. The Bones of the Head are divided into those of the *Skull,* the *Face* and the *Ear.*

69. The Skull is composed of eight bones—the *Front'al,* occupying the portion called the forehead; the two *Tem'poral,* covering the part commonly known as the temples; the two *Pari'etal,* forming the essential part of the projection on the upper and lateral parts of the head and uniting in the median

Fig. 18.


PARIETAL
FRONTAL
TEMPORAL
MALAR
NASAL
SUPERIOR MAXILLARY
VOMER
INFERIOR MAXILLARY
CERVICAL VERTEBRAE
SCAPULA
CLAVICLE
CAPSULAR LIGAMENT
STERNUM
HUMERUS
COSTAL CARTILAGES
LUMBAR VERTEBRAE
RADIUS
ULNA
OS INNOMINATUM
CAPSULAR LIGAMENT
CARPUS
METACARPUS
PHALANGES
FEMUR
PATELLA
FIBULA
TIBIA
TARSUS
PHALANGES
METATARSUS

line upon the top of the skull; the *Occip'ital,* at the posterior part of the skull, resting upon the first vertebra and having a large orifice for the passage of the spinal cord; the *Sphe'-noid,* situated across the base of the skull; and the *Eth'noid* bone, between the sockets of the eyes and behind the base of the nose. (Figs. 18, 19.)

FIG. 19.

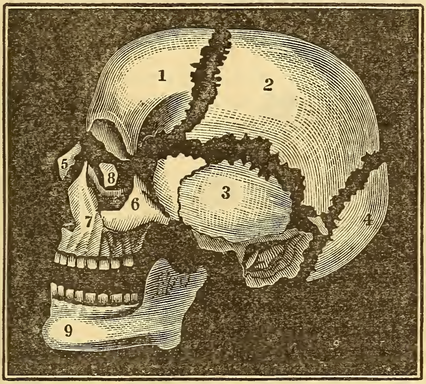


FIG. 19. BONES OF THE HEAD.—1, Frontal bone. 2, Parietal bone. 3, Temporal bone. 4, Occipital bone. 5, Nasal bone. 6, Malar bone. 7, Upper jaw. 8, Os unguis. 9, Lower jaw.

70. The skull-bones are formed of two plates united by porous bone-substance. The *external* plate is fibrous and tough; the *internal,* dense and hard, hence called the *vitreous* or glassy plate. These bones are united by *sut'ures;* the external plate having notched edges fitted together as in the dovetailing of carpentry; the internal, plane edges in simple apposition. From infancy to the twelfth year the sutures are imperfect; from that time to forty, distinctly marked; and in old age, nearly obliterated.

71. The FACE has fourteen bones—the two *Na'sal,* forming the bridge or base of the nose; the two *Ma'lar* (cheek-bones); the two *Lach'rymal;* the two *Superior Max'illary,* articulating

with two bones of the skull and all the bones of the face excepting the lower jaw; the two *Pal'ate* bones, forming the orbits of the eyes, the outside of the nose, and the most of the roof of the mouth known as the hard palate; the two *Tur'-binated*, in the nostrils; the *Inferior Maxillary* (mandible), the only movable bone of the face, articulating with the temporal bones; and the *Vo'mer* which separates the nostrils from each other. (Fig. 19.)

The EAR has three small bones which aid in hearing.

FIG. 20.

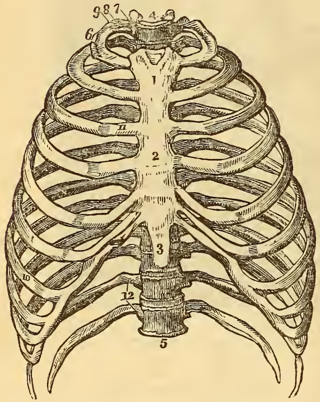


FIG. 21.

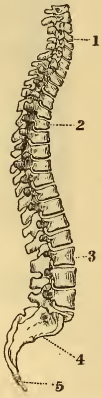


FIG. 20. THE FRONT VIEW OF THE THORAX.—1, 2, 3, The sternum. 4, 5, The spinal column. 6, 7, 8, 9, The first ribs. 10, The seventh rib. 11, Cartilage of the third rib. 12, The floating rib.

FIG. 21. THE SPINAL COLUMN, Lateral view.—1, The Cervical. 2, Dorsal. 3, Lumbar vertebræ. 4, Sacrum. 5, Coccyx.

72. The BONES OF THE TRUNK number fifty-four—twenty-four *Ribs;* twenty-four bones in the *Spinal Column;* four in the *Pelvis;* the *Ster'num* (breast-bone); and the *Os Hyoi'des* (at the base of the tongue). These bones, with the soft parts attached, are so arranged as to form two cavities called the *Tho'rax* (chest) and the *Ab'domen.* (Figs. 20, 21, 22.)

73. The THORAX is formed by the sternum in front, the

ribs at the sides and the twelve dorsal vertebræ at the back. The natural form of the chest is conical, with the apex above. The thorax contains the heart, the lungs and the large blood-vessels. (Fig. 20.)

74. The Sternum is situated in the middle line of the front of the chest, and is held in place chiefly by the ribs. Each side is marked by seven pits for receiving the cartilages of the corresponding true ribs. In childhood the sternum consists of several cartilaginous pieces, which ossify and unite in later years. (Fig. 20.)

75. The Ribs are connected with the spinal column, twelve on each side. The first seven, called *True ribs,* are connected with the sternum by means of cartilage; of the remaining five, called *False ribs,* three are connected by cartilage with each other, while the two lower are free at their anterior extremity, hence called *floating* ribs. (Fig. 20.)

76. The Spinal Column is composed of twenty-four bones, called *Vert'ebræ.* These are arranged in three classes, according to their situation; the seven of the neck are called *Cer'vical;* the twelve of the back, *Dor'sal;* and the five of the loins, *Lum'bar* vertebræ. Between every pair of true vertebræ are plates of white fibrous tissue, called *Interverte-bral Ligaments.* (Fig. 21.)

Fig. 22.

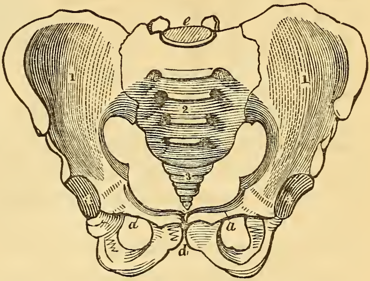


Fig. 22. Front View of the Pelvis.—1, 1, The innominata. 2, The sacrum. 3, The coccyx. 4, 4, Socket. *e*, The junction of the sacrum and lower lumbar vertebra.

77. The Pelvis is composed of the two *Innomina'ta* (nameless bones), the *Sa'crum* and the *Coc'cyx.* (Fig. 22.)

78. The Innominatum is the hip-bone; in it is a deep

socket for the head of the thigh-bone. In the centre of this cavity is a depression to which the round ligament of the thigh-bone is fixed. (Fig. 22.)

79. The SACRUM is a wedge-shaped bone between the innominata. In early life it is composed of five vertebræ, which become united in later years. It is the basis of the vertebral column. The texture of the sacrum is very light and spongy. (Fig. 22.)

80. The COCCYX, at the lower extremity of the spinal column, varies at different ages: in infancy it is cartilaginous; in adult age, formed of four pieces of bone or vertebræ; in after life it becomes a continuous, blended structure. (Fig. 22.)

81. The UPPER EXTREMITIES contain sixty-four bones: the *Scap'ula* (shoulder-blade); the *Clav'icle* (collar-bone); the *Hu'merus* (arm-bone); the *Ra'dius* and *Ul'na* (fore-arm); the *Car'pus* (wrist); the *Meta-car'pus* (palm of the hand); and the *Phalan'ges* (fingers and thumb). (Fig. 18.)

82. The SCAPULA, a flat, thin, triangular bone, is situated upon the upper and back part of the chest. It lies upon muscles by which it is held in place and moved in different directions.

83. The CLAVICLE,* shaped like the italic *f*, is attached at one extremity to the sternum, and at the other to the scapula. (Fig. 18.)

84. The HUMERUS is a long, cylindrical bone, joined at the elbow with the ulna of the fore-arm, and at the scapular extremity lodged in a superficial cavity. (Fig. 18.)

85. The ULNA † is the small bone of the fore-arm, and occupies the inner side. It articulates with the humerus at the elbow, forming a perfect hinge-joint. (Fig. 18.)

86. The RADIUS ‡ is placed on the outside (the thumb side) of the fore-arm, and nearly parallel to the ulna. It is larger than the ulna, and articulates with it, both at the elbow and at the wrist. The radius also articulates with

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* Lat., *clav'is*, a key. † It., a *measure*. ‡ Lat., a *spoke*.

the first row of bones at the wrist forming the wrist-joint. (Fig. 18.)

87. The CARPUS has eight bones, arranged in two rows, and so firmly bound together as to permit little movement. One row articulates with the fore-arm, the other with the metacarpus. (Fig. 23.)

88. The METACARPUS* has five bones, upon four of which are placed the first range of finger-bones, and upon the other the first thumb-bone. The metacarpal bone of the thumb is the shortest, and it is also disconnected with and divergent from the others. (Figs. 23, 24.)

FIG. 23.

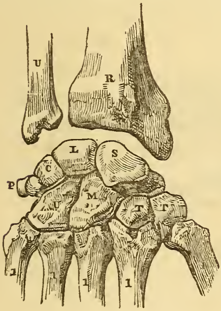

FIG. 24.

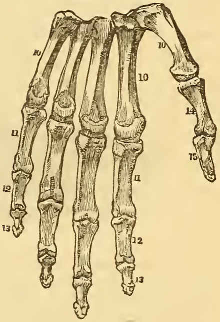

FIG. 23. THE WRIST.—U, The ulna. R, The radius. S, The scaphoid. L, The semilunar. C, The cuneiform. P, The pisiform. The last four form the first row of carpal bones. T, T, The trapezium and trapezoid. M, Magnum. U, Unciform. The last four form the second row of carpal bones. 1, 1, 1, 1, Metacarpal bones.

FIG. 24. THE HAND.—10, 10, 10, The metacarpal bones of the hand. 11, 11, First row of finger-bones. 12, 12, Second row of finger-bones. 13, 13, Third row of finger-bones. 14, 15, The bones of the thumb.

89. The PHALANGES† of the fingers have three bones, while the thumb has but two. The fingers are named, in succession, the thumb, the index, the middle, the ring and the little finger. (Fig. 24.)

90. The LOWER EXTREMITIES contain sixty bones: the

* Gr., *meta*, after or beyond, and *karpos*, wrist. † Gr., *row*.

Fe'mur (thigh-bone); the *Patel'la* (knee-pan); the *Tib'ia* (shin-bone); the *Fib'ula* (small bone of the leg); the *Tar'sus* (instep); the *Metatar'sus* (middle of the foot); and the *Pha-lan'ges* (toes). (Fig. 18.)

91. The FEMUR* is the strongest and longest bone of the skeleton. It supports the weight of the head, trunk and upper extremities.

92. The PATELLA † is a small chestnut-shaped bone, placed on the anterior part of the lower extremity of the femur, and connected with the tibia by a strong ligament.

93. The TIBIA ‡ is situated at the fore and inner part of the leg. It is triangular in shape.

94. The FIBULA § is smaller than the tibia, and of similar shape. It is firmly bound to the tibia at each extremity.

FIG. 25.

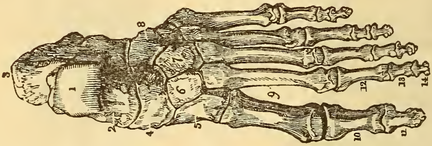

FIG. 25. THE UPPER SURFACE OF THE BONES OF THE FOOT.—1, The surface of the astragulus or ankle-bone, where it unites with the tibia. 2, The body of the astragulus. 3, Calcis or heel-bone. 4, The scaphoid. 5, 6, 7, The cuneiform. 8, The cuboid. 9, 9, 9, The metatarsal bones. 10, 11, The phalanges of the great toe. 12, 13, 14, The phalanges of the other toes.

95. The TARSUS is formed of seven irregular bones, firmly bound together by a few large and strong ligaments, and by a great number of short fibres that extend between the contiguous bones, both on the back and sole of the foot. (Fig. 25.)

96. The METATARSUS consists of five bones; they bear a close resemblance to the metacarpus of the hand. The tarsal and metatarsal bones are so united as to give the foot the form of a double arch. (Fig. 33.)

97. The PHALANGES of the toes have fourteen bones, each

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* Lat., *thigh*. † Lat., *little dish*. ‡ Lat., a *flute*. § Lat., a *clasp*.

of the small toes having three, and the great toe two rows. (Fig. 25.)

98. The JOINTS are formed by the ends of bones, usually enlarged and variously united according to the purposes to be subserved. Generally, one surface is somewhat convex and the other correspondingly concave, the two parts being beautifully fitted to each other; associated with these are the Cartilages, Synovial Membrane and the Ligaments. All the articulations are distributed into three groups—the *Immovable*, the *Mixed* and the *Movable*.

99. The IMMOVABLE JOINTS include the several kinds of suture. A suture is called *Ser'rated** when the zigzag edges are united as in the external plate of the skull; *Squa'mose*, when the edges are beveled so that one overlaps the other, as in the union of the temporal and parietal bones; *Lim'bous*, when the borders of the adjacent bones are elevated, as in the union of the parietal and occipital bones. Sometimes a *false* suture occurs, called *Har'monia*, where the opposed edges are smooth and even, as in the internal plate of the skull and the upper jaw-bones. The fitting of the teeth into their sockets, as a nail is driven into a board, is called *Gompho'sis*:† these are improperly classed with the joints. (Fig. 18.)

100. The MIXED JOINTS are those in which the opposed surfaces of the bones are joined directly together by some intermediate soft substance, which is fibrous externally, and more or less cartilaginous toward its central part, as between the bodies of the vertebræ and the two upper parts of the sternum. (Figs. 20, 21.)

101. The MOVABLE JOINTS are the most perfect articulations, being *freely movable*, for which purpose they are covered with cartilage where the surfaces are in contact, and provided with synovial membrane and connecting ligaments. They are of three kinds—the *Planiform*, the *Hinge* and the *Ball-and-Socket* joints. The *Planiform* is found where the surfaces of the bones are more or less plane and the movements

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* Lat., *serra*, a saw.

† Gr., *gomphos*, a nail.

gliding, as in the articulations of the tarsus and the carpus; of the ribs with the vertebræ, and their costal cartilages with the sternum: The *Hinge* joint (Ginglyform), where there is motion in two directions only, backward and forward, as at the knee: The *Ball-and-Socket* joint, also called *Rotary*, where there is free movement in all directions; it consists of a cup-like cavity in one bone, and a rounded extremity to fit it in the other bone, as in the hip and shoulder joints; the socket at the hip is called the *Acetab'ulum*, at the shoulder, the *Gle'noid* cavity. (Fig. 18.)

§ 7. Histology of the Bones.—*Formation of Temporary Cartilage. Intra-Cartilaginous Mode of Bone-Formation. Periosteum. Endosteum. Cartilages of the Joints. Synovial Membrane. Ligaments.*

102. The primitive basis or *plasma* of the bone is a subtransparent, glairy matter containing numberless minute corpuscles. It gradually acquires firmness and nucleated cells appear, indicating the change into cartilage. As these cells increase in number and size they become aggregated in rows or columns, where ossification is about to begin. In the cartilaginous basis of long bones, these rows are vertical to the *ends;* in that of flat bones, to the *margin.*

Fig. 26.

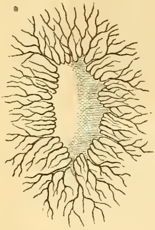

Fig. 27.

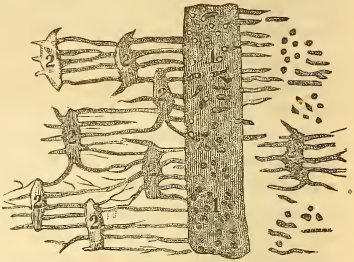

Fig. 26 (*Leidy*). An Osseous Lacuna, exhibiting its numerous diverging canaliculi.
Fig. 27 (*Lessing*). Haversian Canal, lacunæ and connecting canaliculi.

103. The first appearance of *bone* is that of minute granules. Afterward, the cartilage corpuscles become filled with these

granules in all parts excepting their nuclei, which remain isolated in the bony substance. From these proceed minute canals, which become enlarged, forming the cavities called *Lacu'næ.** These everywhere connect with each other by minute tubes called *Canalic'uli.*† One layer of cells after another is thus converted into bony plates, till the whole

Fig. 28.

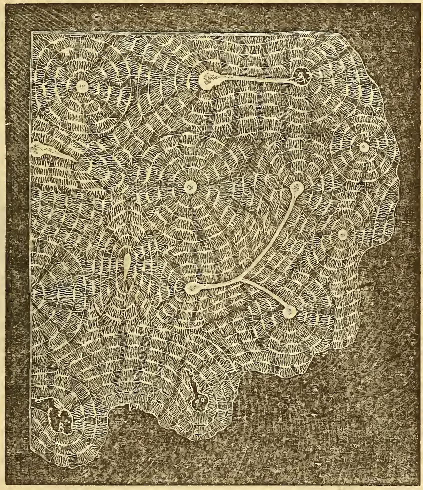

Fig. 28 (*Leidy*). Transverse Section of Bone from the Shaft of the Femur. Highly magnified.—The large circular orifices are transverse sections of the Havers canals, surrounded by layers of osseous substance. Between the latter are seen the lacunæ intercommunicating by means of canaliculi.

column is filled, excepting a fine central tube called the *Canal of Havers.* This microscopic osseous cylinder is called an *os'sicle,* and is a true miniature of any one of the long bones. The compact portion of all bones is made up of these ossicles,

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* Lat., *small pits.* † Lat., *small pipes.*

which, under the microscope, resemble bundles of pipe-stems placed side by side, the interspaces being filled with bone-substance. This mode of bone-formation is called *Intra-cartilaginous.* (Figs. 26, 27, 28.)

104. The long bones are hollow cylinders, compact upon the exterior, and cancellated or spongy within. This open texture increases toward the ends, which it entirely fills, excepting the very thin, hard wall. The cylindrical cavity is filled with a yellowish fat called *Medul'la,** consisting of soft, delicate, adipose cells. (Figs. 29, 30.)

Fig. 29.

Fig. 30.

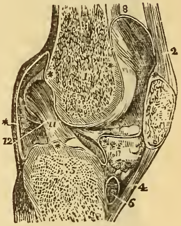

Fig. 29. Longitudinal Section of the Proximal Extremity of the Femur, exhibiting the arrangement of the spongy substance.—1, 2, Positions in which the compact substance appears to resolve itself into a series of arches.

Fig. 30. A Vertical Section of the Knee-Joint.—1, The femur. 3, The patella. 5, The tibia. 2, 4, Ligaments of the patella. 6, Cartilage of the tibia. 12, The cartilage of the femur. * * * *, The synovial membrane.

105. With the exception of the cartilage-tipped extremities, the bones are invested with a dense, white-fibrous membrane called *Peri'osteum;*† and even at the joints it may be traced over the capsular ligaments, thus realizing the opinion of the

* Lat., *marrow.* † Lat., *peri,* around, and *os,* a bone.

ancients that the periosteum formed a complete sac for the whole skeleton. Nor is this true of the external only; for, continuous with the periosteum and lining the medullary cavity and various openings of the bone, there is a web-like and very vascular membrane of extreme tenuity, called *Endosteum** or *Internal Periosteum.*

106. In order to facilitate the movements of bones upon each other, they are covered at the joints with a thinnish layer of CARTILAGE or gristle—a tough, elastic, pearly-white substance, very smooth on the free surface. Upon convex surfaces it is thickest in the centre, while upon concave surfaces it is thickest toward the circumference. This cartilage is sometimes interposed as a ring, forming a movable socket, which, like the friction-wheels of machinery, aids the motion of the joint. This arrangement is seen in the lower jaw, the cartilage being attached to the synovial membrane, but perfectly movable and following the movements of the jaw, thus preventing dislocation. (Fig. 30.)

107. The SYNOVIAL MEMBRANE secretes a viscid fluid called *Syn'ovia,* which lubricates the movable joints. This membrane is of three kinds—the *Articular Capsules,* the *Bur'sæ Muco'sæ* and the *Sub-cutaneous* Synovial Capsules. The *Articular Capsule* forms a complete sac, which covers the articular surface of one bone, and is thence reflected to the other, adhering closely to the borders of each of the cartilaginous surfaces. The *Bursæ Mucosæ* are pouches of synovial membrane interposed between bones and the tendons that play upon them like cords upon pulleys; they also occur where tendons or muscles move upon ligaments, fibro-cartilages, or upon each other. Tendons moving through grooves of bone are enclosed in a synovial tube, which is reflected upon itself so as to line the groove within which the motion takes place. The *Sub-cutaneous Capsule* or membrane is found wherever the skin is frequently moved over a resisting part, as between the skin and patella at the knee. Wherever a

* Gr., *within,* and *os,* bone.

number of tendons move upon one another, this membrane is folded around and among them; it appears to have the same function as the bursæ mucosæ.

Observation.—When the synovial sheath of tendons is ruptured, the synovia passes into the cellular tissue under the skin, forming a tumor called "ganglions" or "weeping sinews." The only means of cure is to close the ruptured sheath.

FIG. 31.

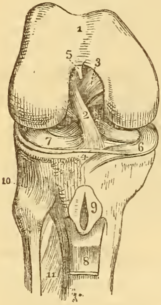

FIG. 32.

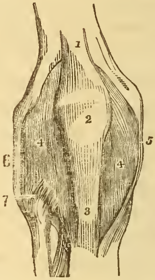

FIG. 31. THE RIGHT KNEE-JOINT, laid open from the front.—1, Articular surface of the femur. 2, 3, Crucial ligaments. 4, Insertion of one of these ligaments into the tibia. 6, 7, Internal and external semi-lunar fibro-cartilages. 8, Ligament of the patella turned down so as to exhibit the synovial bursa (9) beneath. 10, Superior tibio-fibular articulation. 11, Interosseous membrane.

FIG. 32. FRONT VIEW OF THE RIGHT KNEE-JOINT.—1, Tendon of the quadriceps extensor muscle. 2, Patella. 3, Ligament of the patella, or tendinous insertion of the muscle just mentioned. 4, 4, Capsular ligament. 5, 6, Internal and external lateral ligaments. 7, Superior tibio-fibular articulation.

108. Outside the synovial membrane, and more or less connected with it, are the special *ties* of the joints, called LIGAMENTS. These ligaments are composed of white-fibrous tissue, and are named *Cap'sular*, *Band-like* and *Funicular.* The *Capsular Ligaments* are cylindrical sacs extending completely around the joints and blending with the periosteum. This form is found with the ball-and-socket joint. The hip and the shoulder joints furnish perfect examples of the ligamentous capsule. The *Band-like Ligaments* are broad bands

of parallel fibres found with the hinge-joint; and sometimes, where great strength is needed, as accessory to the capsular ligament. The *Funicular Ligaments* are cords round or flat, which extend from one bone to another, sometimes within and sometimes without the joint. An example is seen in the two ligaments crossing each other within the knee-joint, also in the single ligament within and connecting the ball-and-socket joint of the hip. (Figs. 31, 32.)

§ **8.** Chemistry of the Bones.—*Chemical Composition of the Bones. Experiments showing Earthy and Animal Matter.*

109. Bones are composed of both animal and mineral matter, the animal matter being in excess in early life, and the mineral in old age. The average proportion is about thirty-three per cent. animal matter (*cartilage* and *blood-vessels*); and sixty-seven per cent. mineral, of which fifty-one parts are bone-earth (*phosphate of lime*); eleven parts chalk (*carbonate of lime*); the remaining parts are fluor spar (*fluoride of calcium*); *phosphate of magnesia;* and common salt (*chloride of sodium*).

Observation.—To show the earthy without the animal matter, burn a bone in a clear fire, and it becomes white and brittle, the animal part having been consumed. To show the animal without the earthy matter, immerse a slender bone, for a few days, in weak acid (one part hydrochloric or muriatic acid and six parts water), and it becomes flexible, the earthy matter having been removed.

§ **9.** Physiology of the Bones.—*General Uses of the Bones—Adaptation of their Structure to their Uses. Skill as shown in the Skull—In the Spinal Column—In the Ribs—In the Pelvis—In the Upper Extremities—In the Lower Extremities—In the Long Bones. The Uses of the Joints. Classification of the Joints. Of Movable Joints. Function of the Synovia. Of the Cartilages. Of the Ligaments. Of the Periosteum. Perfection of this part of the Animal Fabric.*

110. The Bones serve as the framework of the system; as bases for the attachment of muscles; as levers for the organs of locomotion; as pulleys for the passage of tendons; and as protection for the delicate internal organs. In their

adaptation to their several offices, they exhibit a perfection of mechanism worthy the infinite mind of the DIVINE ARCHITECT.

111. In the minutest structure of the bones, as revealed by the microscope, we find the delicate tissues so disposed as to give the greatest amount of strength and lightness and a certain degree of elasticity—qualities essential to the performance of their several offices. In their more general structure, we see regard to the same qualities, the exterior being dense and compact, the interior spongy or cancellated. Take any bone, or series of bones, and note their peculiar configuration and the purposes to be subserved, and there appears the same marked evidence of special care and skillful mechanism.

112. In the arrangement of the SKULL for the protection of the brain, the oval form (the form best adapted to resist pressure equally applied on all sides); the thickened base where the most important part of the brain lies; the strong and narrow prominences, both in front and back, where most exposed to violence; the tough and hard plates to resist the penetration of sharp substances; the intervening spongy layer to diminish vibrations; the separated bones, and the serrated unions of the external plates, also to lessen shocks; the simple contact of plane edges in the internal vitreous plate, where zigzag edges would be easily broken; the projections, depressions and apertures for the safe passage of nerves and blood-vessels,—all combine to accomplish the one object, *protection*.

113. To construct the SPINAL COLUMN was no easy mechanical problem. These offices were to be taken into the account: it must support the head; furnish an axis of support for the other parts of the body; allow a bending and somewhat rotary movement; furnish a basis for the attachment of muscles; provide passages and protection for the spinal cord and nerves; and the whole must be arranged with reference to the importance and delicacy of the brain. The number of vertebræ, the cartilage cushions and the four

curves of the column all tend to secure the brain from shocks it would otherwise receive from walking, leaping and running.

114. The Ribs serve to protect the delicate organs of the chest. These slender bones should be elastic and movable: the first quality is secured by the cartilaginous union to the sternum; the second, by their cartilages, their articulations with the spine, and their oblique position.

115. The Pelvis not only furnishes support for the upper part of the body and the articulations of the lower extremities, but also serves as a base for the attachment of the powerful erector muscles of the spine, the muscles for moving the lower limbs, and the muscles which shut in the abdominal and pelvic cavities.

116. The form and proportion of the Upper Extremities relate to the *hand*, which belongs exclusively to man, and gives the power of execution to the human mind: thus, the arm is longer than the fore-arm, and this longer than the hand, securing greater mobility, flexibility and power of adaptation as we approach the delicate organs of prehension. It is the relative position of the four fingers to the thumb, however, which principally stamps the character of the hand, as this construction permits its adaptation to every shape, and gives that complete dominion which it possesses over the various forms of matter.

117. The Lower Extremities have a strong analogy to the upper, the differences being only such as are necessary to constitute them organs of locomotion rather than of prehension; hence, their *solidity* at the expense of their *mobility*. The *shafts of long bones* are made hollow, giving not only lightness but strength, according to the well-known principle in mechanics, that, with a given amount of material, a hollow cylinder will sustain more weight than a solid one, both being of the same height.

118. The Joints. The uses of the *joints* are to enable the body to sustain greater weight (as several short pillars will support more weight than a single pillar of the same height and thickness); to diminish the force of blows or shocks; to

afford freedom of movement; to provide fulcrums for the various levers; to modify the direction in the action of muscular power, and to determine the plane of action.

119. For simple union without movement, we find the Immovable joint; for great strength and little movement, the Mixed joint; and for full freedom of movement, the Movable joint. Of the movable joints for motion in one plane and two directions, we find the Hinge-joint; for the gliding movement, the Planiform joint; and for free rotary motion, the Ball-and-Socket joint. (Figs. 18, 30, 31.)

Fig. 33.

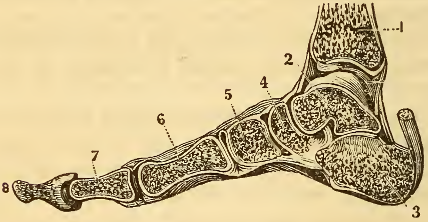

Fig. 33. A Side View of the Bones of the Foot, showing its Arched Form. The arch rests upon the *heel* behind, and the *ball* of the toes in front.—1, The lower part of the tibia. 2, 3, 4, 5, Bones of the tarsus. 6, The metatarsal bone. 7, 8, The bones of the great toe.

120. The use of the Synovia is to enable the surfaces of the bones to move more easily upon each other, preventing friction and consequent wear. No machine of human invention manufactures for itself the necessary lubricating fluid, but in the animal mechanism it is supplied in proper quantities, applied in the proper places and at the proper time.

121. Cartilage tips the articular extremities of bones, facilitating the sliding motion and deadening shocks; and in various parts of the body it serves as an elastic cushion, yielding on compression and regaining its form when the pressure is removed. (Figs. 30, 31.)

122. The function of the Ligaments is to bind together

the bones of the system. By them the lower jaw is bound to the temporal bones, and the head to the neck; they extend the length of the spinal column, between the vertebræ, and from one spinous process to another; they bind the ribs to the vertebræ and the sternum; the sternum to the clavicle; the clavicle to the first rib and the scapula; the scapula to the humerus; the bones of the fore-arm at the elbow-joint, and also at the wrist; the bones of the wrist to each other, and to those of the hand; and these to each other, and to those of the fingers and thumb. In the same manner they bind the bones of the pelvis together; and these to the femur or thigh-bone; and this to the two bones of the leg and the patella or knee-pan; and so on to the ankle, foot and toes, as in the upper extremities. The bones of the wrist and those of the foot are as firmly fastened as if bound by clasps of steel.

123. The PERIOSTEUM serves to transmit blood-vessels into the bone, thus furnishing nutriment; it gives insertion to muscles, tendons and ligaments; obviates the effects of friction; strengthens the whole skeleton as an investing membrane, and possesses some agency in the process of ossification.

124. We have noticed but a few of the many wonderful examples of skill, wisdom and benevolence exhibited in the internal framework of the animal fabric. Each bone, however small, illustrates some profound principle of science; each is perfect in its adaptation to a specific use. The whole structure is a faultless piece of mechanism, in which every known principle of architecture and dynamics has been brought into service.

§ **10.** HYGIENE OF THE BONES.—*Effect of Exercise upon the Bones of Children. Effect of Compression—Of Stooping. Treatment of Fractures—Of Sprains—Of Felons.*

125. *The health of the bones is promoted by regular exercise.* The kind and amount of labor should be adapted to the age, health and development of the bones; neither the cartilaginous

bones of the child, nor the brittle bones of the aged man, are adapted to long-continued and severe exercise. While protracted exercise in childhood is injurious, moderate and regular labor favors a healthy development and consolidation of the bones.

126. *The lower extremities of the very young are not adapted to sustaining much weight;* hence, to induce a child to walk, or to stand by chairs, while the bones of the lower limbs are imperfectly developed, is ill advised and productive of serious injury; "bow" legs are thus produced. The benches or

Fig. 34. Fig. 35.

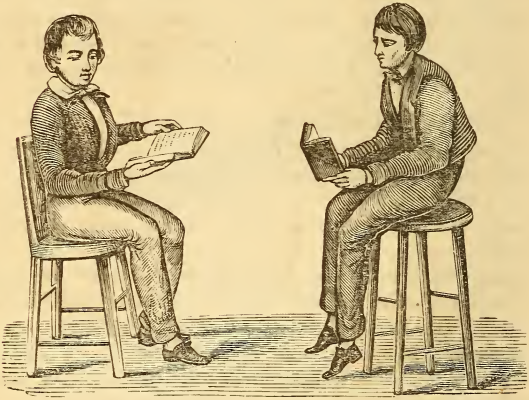

Fig. 34. Position when the feet are supported.
Fig. 35. Position when a seat is too high.

chairs for children in a school-room should permit the feet to rest upon the floor, otherwise the weight of the limbs below the knee may cause the flexible bone of the thigh to become curved; the chairs should also have suitable backs, and the child be allowed frequent change of position. (Figs. 34, 35.)

127. *Compression of the chest should be avoided.* In youth the ribs are very flexible, and a small amount of pressure will increase their curvature, particularly at the lower part

of the waist. By tight or "snug" clothing the ribs are drawn down and the space between them lessened, so that in some instances the anterior extremities of the lower ribs are brought quite together; hence, the apparel should be loose and supported by the shoulders, both for children and adults.

128. *An erect position both in sitting and standing should be carefully maintained.* The spinal column naturally curves from front to back, but not from side to side. The admirable arrangement of the bones and cartilages permits a great variety

Fig. 36.

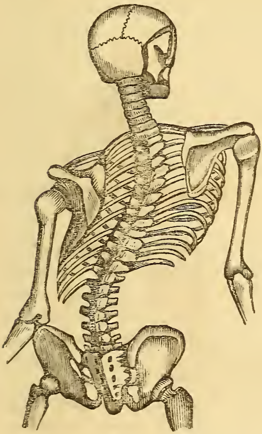

Fig. 37.

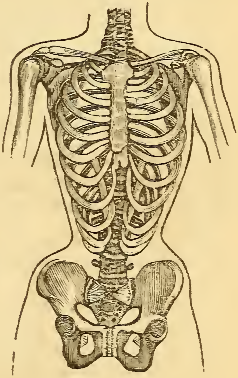

Fig. 36. A Deformed Thorax and Spinal Column.
Fig. 37. A Chest Fashionably Deformed.

of motions and positions, the elasticity of the cartilages always tending to restore the spine to its natural position; but if a stooping or a lateral curved posture be continued for a long time, the compressed edges of the cartilages lose their power of reaction, and finally one side becomes thinned, while the other is thickened. These wedge-shaped cartilages produce permanent curvature of the spine, which is often attended with disease of the spinal cord. (Figs. 36, 37.)

129. The student, seamstress and artisan frequently acquire a stooping position by inclining forward to bring their books or work nearer the eyes. The desk of the pupil is often higher than the elbow as it hangs from the shoulder at rest, consequently, in drawing, writing and often in studying, one shoulder is elevated and the other depressed, distorting the spine. In the daily employments of life, children should early be taught to use the left hand and shoulder more freely. Distortions of the chest necessarily accompany deformity of the spine, and disease of the heart and lungs follows, compared to which the loss of symmetry is a minor consideration.

130. Eminent physicians both in this country and Europe state that, among the fashionably educated, not one female in ten escapes deformities of the shoulders and spinal column. The student, to prevent as well as to cure slight curvatures of the spine, should walk with a book or a heavier weight upon the head. Porters and laborers of some countries bear very great burdens upon their heads, and walk at a rapid pace with comparative ease.

Observation 1*st.—Fractured or diseased bones and ligaments should receive special attention.* In *fractured bones,* a surgeon's care is not only needed to adjust the parts, but for several weeks to watch the reunion, that the limb may not be crooked or shortened. In *sprains,* the ligaments are not usually lacerated, but strained and twisted, causing much pain, and afterward inflammation and weakness of the joints. To effect a cure, there should be absolute *rest* for days, and perhaps weeks, using tepid bathing and prolonged moderate friction. More persons are crippled from ill-cared-for sprains than fractured bones. Persons enfeebled by disease, particularly scrofula, cannot be too assiduous in adopting an early and proper treatment of injured joints, to prevent the affection called "white swelling."

Observation 2*d.*—The disease called "*Felon*" is an inflammation that commences in or beneath the periosteum. It is attended with severe, throbbing pain, and the unyielding structure of the parts prevents much swelling. The only *successful* treatment of this painful affection is an *early, free* opening through the periosteum to the surface of the bone. The earlier the incision is made, the less the risk and the suffering. The same treatment must be adopted in inflammation of large bones.

§ **11.** COMPARATIVE OSTEOLOGY.—*Classification of Animals according to their Plan of Structure. Classification of Vertebrata. Compare Bones of the Head of Vertebrates — The Vertebral Column — The Thorax—The Extremities. Characteristics of Annulosa—Mollusca—Radiata—Protozoa.*

131. The tissues, cells and chemical composition of all animals are essentially the same, but the different appointments in the plan of creation require special conformations. Animals have therefore been arranged, according to their *plan of structure,* into two divisions—*Vertebrata* and *Invertebrata;* these into five sub-kingdoms—*Vertebra'ta, An'nulosa* (Articulata), *Mollus'ca, Radia'ta* and *Protozo'a.**

FIG. 38.

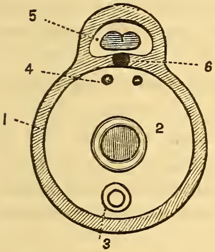

FIG. 39.

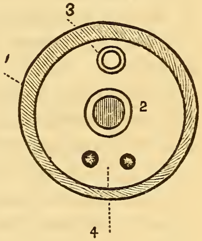

FIG. 38. DIAGRAM OF A TRANSVERSE SECTION OF A VERTEBRATE.—1, The walls. 2, The digestive organs. 3, The hæmal. 4, The ganglia. 5, The spinal cord. 6, Spinal column.

FIG. 39. DIAGRAM OF A TRANSVERSE SECTION OF AN INVERTEBRATE.—1, The walls. 2, The digestive organs. 3, The hæmal organs. 4, The ganglia.

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* The brief outlines of Zoology introduced in this work are arranged into *two divisions,* from Lamarck. Writers on Natural History, as Linnæus, Cuvier, Edwards, Nicholson and others, have adopted different sub-kingdoms numerically. I have chosen to arrange them into five *sub-kingdoms.*

When organs in different animals agree with one another in the plan of *structure,* they are said to be "*homologous;*" as the arm of a man, the wing of a bird. When organs in different animals perform the same *functions,* they are said to be "*analogous;*" as the wing of a bat, the wing of a fly. In the great diversity of animals and in their varied structures, they may be *both* homologous and analogous, or in part homologous and in part analogous, or homologous and not analogous.

132. If a Vertebrate is divided transversely, two separate cavities are brought to view: the posterior or upper cavity contains the cerebro-spinal axis (spinal cord); the other, the ganglia, the hæmal or circulatory and the digestive organs. If an Invertebrate is divided transversely, only one cavity is seen; this contains the hæmal and digestive organs, with the ganglia. In Vertebrates the ganglia are placed on the dorsal or upper side of the cavity, and the hæmal organs on the ventral or lower side. In Invertebrates the ganglia are found on the lower and the hæmal organs on the upper side.

133. The sub-kingdom *Vertebrata* have an *internal* skeleton; in general, a spinal column or back-bone. A distinctive characteristic of vertebrates is that the brain and spinal cord are shut off from the general cavity of the body. In this sub-kingdom are classed *Mammals, Birds, Reptiles, Amphibians* and *Fishes.*

134. Mammalia or Mammals include Man and all the ordinary quadrupeds.

135. Birds are oviparous,* vertebrate animals, with a double circulation, and covered with feathers.

136. Reptiles comprise a class of vertebrates with incomplete circulation, breathe air from birth, and are generally covered with scales or plates.

137. Amphibians are so formed as to live on land, and for a long time under water. Their distinguishing characteristic is that they invariably undergo some kind of metamorphosis after birth. At first the general conformation of the body resembles fishes; at this stage they breathe by gills, subsequently they change form, and in their adult state possess air-breathing lungs. The skin is generally naked.

138. Fishes are oviparous, vertebrate animals, and breathe by gills. They differ in the form of their bodies, but the outline is simple. They are usually covered with scales.

139. The Bones of the Head of other *Mammals* resemble, in many points, those of man. In some quadrupeds,

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* Lat., *ovum*, egg, and *pario*, to produce.

as the horse and the cow, the frontal bone is in two parts; in others, the two parietal bones are united: between the two upper maxillary bones are two small bones called *inter-maxillary;* the lower jaw consists of two pieces. In *Birds,* the bones of the head, in number and position, resemble mammals, but they are early united, leaving no trace of the sutures. The superior mandible or upper jaw of the bird is so articulated with the cranium as to admit of motion independent of the lower jaw (which never occurs in mammals), and the inferior mandible, instead of being articulated directly with the cranium, is connected through the intermedium of a distinct bone called the *Os Quadratum.* In *Reptiles* the head-bones are irregular in form, and greatly vary in number. In *Amphibia* the skull always articulates with, or is jointed to, the spinal column by two articular surfaces or condyles. In *Fishes* the bones of the head are numerous and irregular, and their study is a matter of much interest in acquiring a full knowledge of Natural History. (Figs. 18, 40, 41.)

140. The Vertebral Column of other *Mammals,* with slight modifications, is like that of man. The difference is chiefly in the number of the vertebræ in the caudal part of the column. The number of cervical vertebræ is almost *invariably* seven; the dorsal average thirteen; the lumbar, from three to seven; the sacral, usually four; the caudal, from four (the number of the coccyx in man) to forty-six. The length of any part of the column seems to depend not so much upon the *number* of the vertebræ as upon their *length;* thus we find seven cervical vertebræ in the long-necked Giraffe and in the short-necked Mole. In *Birds,* the flexibility of the neck enables any part of the body to be reached by the beak. This is owing to the ball-and-socket articulations, and to the great number of cervical vertebræ, which in the Swan are twenty-four. The dorsal vertebræ vary from seven to eleven, and are generally consolidated into one, but in birds that do not fly they remain distinct and movable. The lumbar and sacral vertebræ are united into one. The last caudal vertebræ has a large, strong process, shaped like the letter V, for the

support of the large feathers, which act as a rudder in flight. In *Reptiles* the vertebræ vary in number from twenty-four to four hundred, as in the serpent called Python. In *Amphibians* sometimes the vertebræ are hollow at both ends, and some-

Fig. 40.

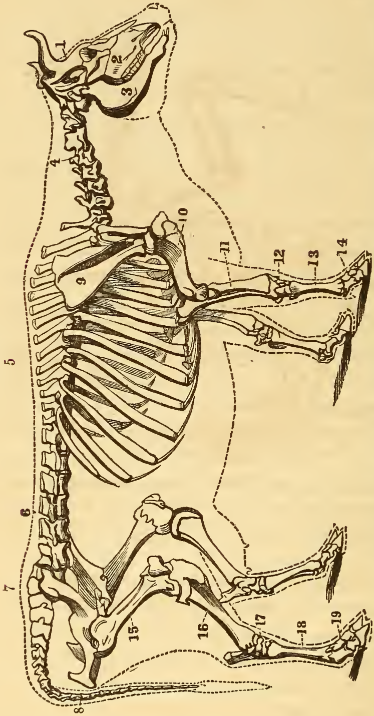


Fig. 40. Skeleton of the Cow.—1, Frontal bone of the head. 2, Upper jaw (superior maxillary). 3, Lower jaw (inferior maxillary). 4, Cervical vertebræ. 5, Dorsal vertebræ. 6, Lumbar vertebræ. 7, Sacral vertebræ. 8, Caudal vertebræ. 9, Scapula. 10, Humerus. 11, Radius and ulna. 12, Carpus. 13, Metacarpus. 14, Phalanges (toes). 15, Femur. 16, Tibia. 17, Tarsus. 18, Metatarsus. 19, Phalanges. In this fig. the same terms are used as for the corresponding bones in man (see fig. 18). The common names vary.

times hollow behind and rounded in front. In Frogs the spinal column is short; the dorsal vertebræ are very long. In *Fishes* there are but two kinds of vertebræ, the dorsal and the caudal, and these vary in number from twenty to two

hundred. The vertebral bodies present a conical, cup-like depression on each side, which contains a gelatinous fluid having the same use as the elastic intervertebral substances in mammals. (Figs. 18, 40, 41, 42, 43.)

FIG. 41.

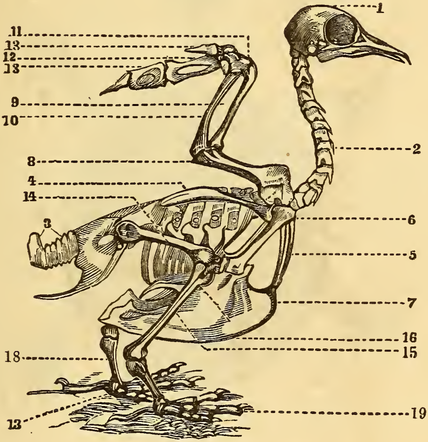


FIG. 41. SKELETON OF A BIRD.—1, The head. 2, Cervical vertebræ. 3, Dorsal and lumbar vertebræ. 4, Scapula. 5, Clavicle. 6, Coracoid bone. 7, Sternum. 8, Humerus. 9, Radius. 10, Ulna. 11, Carpus. 12, Metacarpus. 13, 13, Phalanges (fingers). 14, Femur. 15, Tibia. 16, Fibula. 17, Tarsus. 18. Metatarsus. 19, Phalanges (toes).

141. The STERNUM of *Mammals* in general is flat and smooth. In *Birds* it is much extended, and forms the largest bone in their bodies. It has upon its anterior surface a *ridge* resembling the keel of a ship, for the support of the pectoral muscles used in flying. The size is proportioned to the powers of flight; hence, in the little Humming-bird, which is on the wing most of the day, it reaches the maximum of development. Of the *Reptiles*, Serpents have no sternum, but in Turtles it has an extraordinary development, and extends from the base of the neck to the commencement of the

tail, forming the ventral part of the shell-covering. In some *Fishes*, the sternum is represented by a *chain* of bones.

FIG. 42.

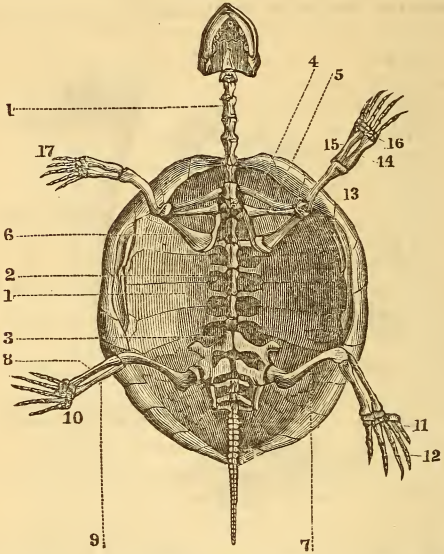


FIG. 42. SKELETON OF A TORTOISE.—1, Cervical, 2, Dorsal, 3, Lumbar vertebræ. 4, Scapula. 5, Clavicle. 6, Coracoid bone. 13, Humerus. 14, Ulna. 15, Radius. 16, Carpus. 17, Phalanges (fingers). 7, Femur. 8, Tibia. 9, Fibula. 10, Tarsus. 11, Metatarsus. 12, Phalanges (toes).

142. The RIBS are much alike in *Mammals*, generally in twelve pairs; in the Horse, however, there are eighteen pairs. In *Birds* the cartilage that unites the rib to the sternum is osseous, giving solidity to the chest. In some *Reptiles* —as Lizards and Crocodiles—the ribs are more numerous than in mammals and birds, and protect the abdomen as well as the chest. In the Turtle the ribs are expanded, forming the dorsal part of its shell, or the roof of its portable dwelling-house. In Serpents the lower or anterior extremities of

the ribs have no cartilage; they aid in progressive movement or crawling, as under the skin their ends can be placed on the ground like feet. Of the class *Amphibia,* Frogs and Toads have no ribs. In Newts they are rudimentary. In some *Fishes* the ribs are wanting; in others they are very complete, and surround the trunk; in still others they are connected with a chain of bones representing the sternum. (Figs. 18, 40, 41.)

143. The Upper Extremities in *Mammals* are never wanting. In animals that swim or burrow the humerus is short, thus enabling the fore limbs to be used with force; where swiftness is required, this bone is long and slender. When the hand is used for *support* instead of prehension, the radius loses its power of rotation on the ulna. In the Horse and other solid-hoofed animals the same obtains with the fibula and tibia. In mammals the hand varies. The fingers or toes are never more than five. The middle finger is the most persistent, being the only one left in the horse. In *Birds* the humerus is larger and stouter than the thigh-bone, contrary to the relative proportion in man.

144. The obvious use of the Clavicle is to maintain the shoulders apart; hence in quadrupeds, where its presence would be a defect, it is wanting, as in the horse and cow. The clavicles of *Birds* are peculiar; they unite at their anterior extremity, forming a forked bone called *furcula,* or wishbone. In birds of powerful flight, as the Eagle, the clavicles are very strong; in others, as the domestic Turkey, they are weak. Connecting the scapula to the sternum is the *cor'acoid* bone, which is placed side by side with the furcula, and is the main source of support to the wings in flight. In some *Reptiles,* as the Tortoise, both the clavicle and the coracoid bone are found, while in others, as Serpents, both are wanting. In *Fishes* the true clavicle is wanting, but in some species there is a modified form of the coracoid bone, free at its lower extremities, which may, perhaps, be considered as homologous with the coracoid bone or clavicle of the higher animals.

145. The Scapula is present in *Mammals, Birds* and most *Reptiles* and *Fishes.* In the horse and cow it is an essential

bone. In *Birds* the scapula is long and narrow. *Reptiles, Amphibians* and *Fishes* have in general the scapula, but variously modified.

146. The LOWER EXTREMITIES in *Mammals* are sometimes absent, as in Whales. In quadrupeds, as they are used mainly for support and progression, they are less modified than the upper extremities. In *Birds* the femur is short and straight.

FIG. 43.

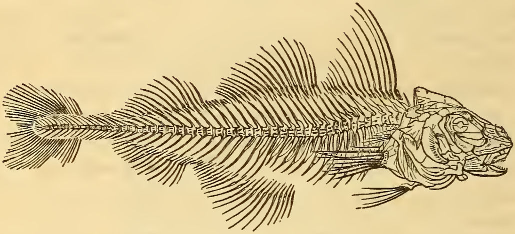


FIG. 43. THE SKELETON OF A HADDOCK.

The tibia is the chief or longest bone of the hind limb. The fibula is united to the tibia at various distances down the leg. In some *Reptiles*, as the Tortoise and Lizard, the anterior and posterior limbs are composed of bones, which in number, form, position and functions much resemble the corresponding ones in mammals and birds. In the Serpent tribe the limbs are wanting. In *Amphibians* the limbs are well developed. In *Fishes* the extremities are rudimentary, being represented by fins.

147. The ANNULOSA* are numerous, embracing animals having an external skeleton made up of segments or rings arranged along a longitudinal line, and consisting mostly of hardened skin. They have a distinct alimentary canal shut off from the general cavity of the body. The hæmal organs may be absent, but when present are found on the dorsal aspect. The nervous system is of connected ganglia on the ventral side. The limbs, when present, are turned to the

* Lat., *Annulus*, a ring.

neural (nerve) aspect. This sub-kingdom is separated into two divisions, which include many classes and orders, and embrace Beetles, Weevils, Bees, Wasps, Butterflies, House-flies, Fleas, Millipedes, Centipedes, Spiders, Scorpions, Lobsters, Crabs, Worms, Leeches. (Figs. 44, 45.)

Fig. 44.

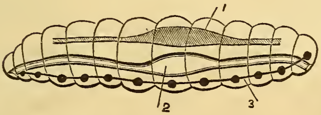


Fig. 45.

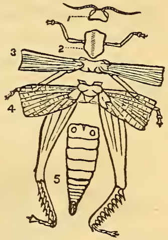


Fig. 44. Diagram of an Annulosa.—1, Hæmal or vascular system. 2, Digestive organs 3, Ganglia.

Fig. 45. Diagram of the External Structure of an Insect.—1, The head carrying the eyes and antennæ. 2, First segment of the thorax with the first pair of legs. 3, The second segment of the thorax with the second pair of legs and the first pair of wings. 4, The third segment of the thorax with the third pair of legs and the second pair of wings. 5, Abdomen without legs.

148. Mollusca* are mostly soft-bodied animals that are usually protected by an external skeleton or shell composed of the carbonate of lime. They have an alimentary canal that is shut off from the general cavity of the body. If a

Fig. 46.

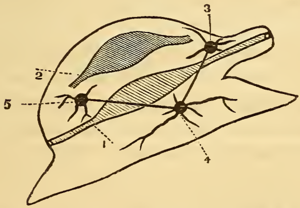


Fig. 47.

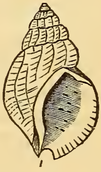


Fig. 46. Diagram of a Mollusca.—1, Alimentary canal. 2, Heart. 3, Cerebral ganglion. 4, Pedal ganglion. 5, Ganglion of digestive organs and muscles.

Fig. 47. A Species of Snail.—1, A round mouth.

* Lat., *Mollis*, soft.

hæmal apparatus exists, it is on the dorsal side. The lower order have one ganglionic mass; the higher Mollusca have three ganglions connected by nervous cords. The digestive organs extend the whole length through the centre of the cavity of the body. The Mollusca are separated into two divisions, each of which is divided into classes and orders, embracing the Nautilus, Cuttle-fishes, Snails, Limpits, Whelks, Muscles, Oysters, Scallops, Seamats, etc. (Figs. 46, 47.)

149. The RADIATA embrace animals whose organization is much less complete than that of most other animals. The alimentary canal communicates with the general cavity of the body. The nervous system is rudimentary or wanting. Distinct reproductive organs exist in all. Peculiar stinging organs, "nettle-cells," are usually present; and the different parts of the economy, instead of being disposed in pairs on each side of a longitudinal plane, are grouped around a central point or axis.

FIG. 48.

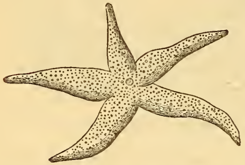


FIG. 48. DIAGRAM OF A RADIATA.—The Star-fish.

150. The PROTOZOA* forms the lowest division of the animal kingdom. They are generally of very minute size, are composed of a jelly-like substance, having no distinct internal cavity, no nervous system, and the alimentary apparatus rudimentary or wanting. Most of them are only seen by the aid of the microscope. They abound in the air, are largely found in water, and are popularly called "animalculæ," or "parasites." Some few attain a large size, as the sponge.

Suggestion.—The varied structure of the four lower sub-kingdoms of animals is replete with interest and instruction, but the necessarily limited space of this elementary school-book entirely precludes their consideration. Allow us to advise all who can command the leisure to extend this study to the beautiful and wonderful works of creation as seen in these parts of the garden of the Lord.

* Gr., *protos*, first, and *zoön*, an animal.

ANALYTIC EXAMINATION.

66 Why is the Motory Apparatus so called? Name its organs.

Chapter IV.—The Bones.

§ **6.** *Anatomy of the Bones.*—67. Of what does the Internal Framework of the body consist? State the number and classes of the bones. 68. Name the division of bones of the Head. 69. How many bones compose the Skull? Give their names and positions. 70. What is said of the skull-bones? How are they united? 71. How many bones in the face? Name and describe them. The Ear has how many bones? 72. State the number and names of the bones of the Trunk. 73. How is the Thorax formed? What its natural form? What organ does it contain? 74. What is said of the Sternum? 75. Describe the Ribs. Distinguish between true and false. Why the floating ribs so called? 76. Of what is the Spinal Column composed? How arranged? Speak of the Intervertebral ligaments. 77. Of what is the Pelvis composed? 78. Describe the Innominatum. 79. What is the Sacrum? 80. What changes occur in the Coccyx during life? 81. Mention the number and names of the bones of the Upper Extremities. 82. Where is the Scapula situated? 83. To what is the Clavicle attached? 84. Describe the Humerus. 85. What is the Ulna? 86. What is the position of the Radius? With what does it articulate? 87. Speak of the number and arrangement of the bones of the Carpus. 88. State the arrangement of the Metacarpal bones. 89. How many bones in the phalanges of the fingers? 90. How many in the Lower Extremities? What their names? 91. What is said of the Femur? 92. Patella? 93. Tibia? 94. Fibula? 95. Tarsus? 96. Of how many bones does the Metatarsus consist? 97. How many do the phalanges of the toes contain? 98. How are joints formed? Name the groups of articulations. 99. Mention and describe each kind of immovable joints. 100. What are the mixed joints? Give examples. 101. What is said of movable joints? How many kinds? Describe each.

§ **7.** *Histology of the Bones.*—102. What is the character of the primitive basis of bone? State the changes previous to ossification. 103. State the mode of ossification. 104. What are the structure and texture of the long bones? Where is the Medulla found? 105. Distinguish between the Periosteum and Endosteum. 106. Of what service is Cartilage? How arranged? 107. Of what use the Synovial membrane? Name and describe its kinds. Observation. 108. What are found in connection with the Synovial membrane? Describe the several kinds of ligaments.

§ **8.** *Chemistry of the Bones.*—109. Of what are the bones composed? Mention the mineral constituents. Observation.

§ **9.** *Physiology of the Bones.*—110. Name the uses of the Bones. 111. What qualities found in bones? 112. What advantages result from the structure and arrangement of the skull-bones? 113. Mention the offices of the spinal column. 114. What purpose do the Ribs serve? 115. State the offices of the Pelvis. 116. What is said of the form and proportion of the Upper Extremities as relating to the hand? 117. Compare the Lower Extremities with the Upper. Why are the shafts of the long bones hollow? 118. Enumerate the uses of the joints. 119. State the purposes of the different classes of joints. 120. Give the use of the Synovia. 121. What is said of Cartilage? 122. Speak of the function of the Ligaments. 123. Of what service the Periosteum? 124. What is illustrated by each bone?

§ **10.** *Hygiene of the Bones.*—125. What is the influence of exercise on the health of the bones? How should it be taken? 126. To what are the lower extremities of the very young not adapted? 127. What should be avoided? Why? 128. Why should an erect position be maintained? 129. How are distortions of the body produced? 130. What statement by eminent physicians? How may slight curvatures of the spine be prevented or cured? Observations.

§ **11.** *Comparative Osteology.*—131. Name the divisions of the animal kingdom. 132. Give the distinctions of the two divisions. 133. Give the classes of the vertebrata. 134. What animals are included in the class Mammalia? 135. Name the characteristics of Birds. 136. Of Reptiles. 137. Of Amphibians. 138. Of Fishes. 139. What is said of the bones of the head in Mammals? Birds? Reptiles? Amphibia? Fishes? 140. Compare the vertebral column of Mammals. What is said of it in Birds? Reptiles? Amphibia? Fishes? 141. Speak of the sternum of Mammals. Birds. Reptiles. Fishes. 142. Describe the ribs in the different classes. 143. Give the use of the upper extremities in some Mammals. In Birds. 144. Why not a clavicle in the ox? Describe the clavicle of Birds. Reptiles. Fishes. 145. Describe the scapula in Mammals. 146. Speak of the lower extremities in Mammals. Birds. Reptiles. Amphibians. Fishes. 147. Describe the sub-kingdom Annulosa. 148. The Mollusca. 149. The Radiata. 150. The Protozoa.

UNIFIC REVIEW.

[Compare 67 with 131–133 and 147–150.]

What constitutes the Skeleton? What is said of it in the different sub-kingdoms?

[Compare 68–71 with 139.]

Compare the bones of the Head of man with those of the other classes of vertebrata.

[Compare 72–80 with 140–142.]

Name the bones of the Trunk. Are they all found in the lower animals? Compare these bones in the different classes of vertebrata.

[Compare 81–89 with 143–145.]

Name the bones of the Upper Extremities. What peculiarity in these bones in some animals?

[Compare 90–97 with 146.]

Describe each bone of the Lower Extremities.

[Compare 102, 103 with 7–11 and 131.]

What is said of the earliest organic form of living things?

[Compare 105 with 17 and 123.]

What tissue in the Periosteum? Use of this membrane?

[Compare 108 with 17.]

What tissue forms the Ligaments?

[Compare 109 with 40, 49 and 63.]

Name both the organic and inorganic matter in bones.

[Compare 125 with 185, 261 and 330.]

What is necessary to the health of the bones?

FIG. 48.

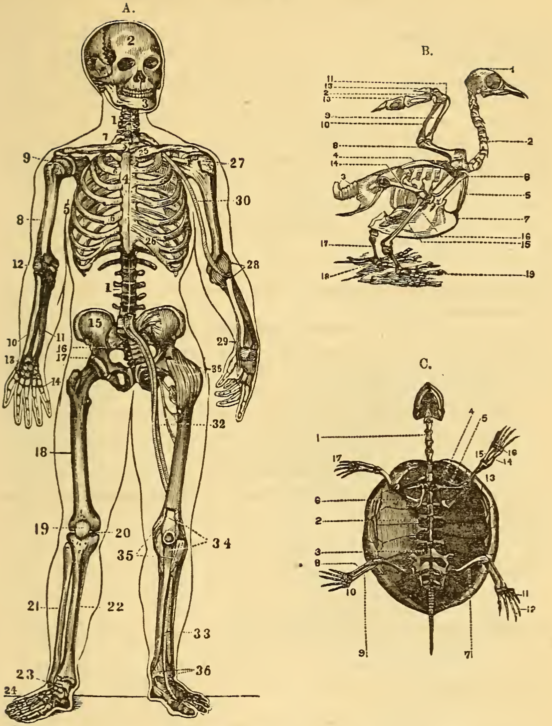


FIG. 48. A. HUMAN SKELETON.—1, 1, Spinal column. 2, Skull. 4, Sternum. 5, Ribs. 7, Clavicle. 8, Humerus. 10, Radius. 11, Ulna. 13, Wrist. 14, Hand. 15, Haunch-bone. 16, Sacrum. 18, Thigh-bone. 19, Patella. 21, Fibula. 22, Tibia. 23, Ankle-joint. 24, Foot. 25, 26, Ligaments of the clavicle, sternum and ribs. 27, 28, 29, Ligaments of the shoulder, elbow and wrist. 30, Brachial artery. 31, Ligaments of the hip-joint. 34, 35, 36, Ligaments of the patella, knee and ankle.

B. SKELETON OF A BIRD.—1, The head. 2, Cervical vertebræ. 3, Dorsal and lumbar vertebræ. 4, Scapula. 5, Clavicle. 6, Coracoid bone. 7, Sternum. 8, Humerus. 9, Radius. 10, Ulna. 11, Carpus. 12, Metacarpus. 13, 13, Phalanges (fingers). 14, Femur. 15, Tibia. 16, Fibula. 17, Tarsus. 18. Metatarsus. 19, Phalanges (toes).

C. SKELETON OF A TORTOISE.—1, Cervical, 2, Dorsal, 3, Lumbar vertebræ. 4, Scapula. 5, Clavicle. 6, Coracoid bone. 13, Humerus. 14, Ulna. 15, Radius. 16, Carpus. 17, Phalanges (fingers). 7, Femur. 8, Tibia. 9, Fibula. 10, Tarsus. 11, Metatarsus. 12, Phalanges (toes).

SYNTHETIC TOPICAL REVIEW.

The Skeleton and its uses, Number and classes, Head, Trunk, Upper Extremities, Lower Extremities, Joints, Definition and classes of Joints, Immovable Joints, Mixed, Movable, Peculiar forms of Movable.	§ 6. *Anatomy of.*	Chap. IV. *The Bones.*
Formation of Temporary Cartilage, Intra-cartilaginous mode of ossification, Structure of the Long Bones, Periosteum, Endosteum, Cartilages of the Joints, Synovial membrane, Ligaments.	§ 7. *Histology of.*	
Chemical Composition, Experiment showing earthy and animal matter.	§ 8. *Chemistry of.*	
General uses of, Adaptation of their structure to their uses, Skill as shown in the Skull, " " Spinal Column, " " Ribs, " " Pelvis, " " Upper Extremities, " " Lower Extremities, " " Long Bones, The uses of the Joints, Classification of the Joints, Of Movable Joints, Function of the Synovia, " Cartilages, " Ligaments, " Periosteum, Perfection of this part in the animal fabric.	§ 9. *Physiology of.*	
Effect of exercise upon the bones of children, " compression, " stooping, Treatment of Fractures, " Sprains, " Felons.	§ 10. *Hygiene of.*	
Classification of Animals, " Vertebrates, Compare Spinal Column of Vertebrates, " Bones of the Head, " " Thorax, " " Extremities, Classification of Invertebrates.	§ 11. *Comparative Osteology.*	

Give the Human and Comparative Anatomy and Histology of the Bones; the Chemistry, the Physiology and the Hygiene.

CHAPTER V.

THE MUSCLES.

§ **12.** ANATOMY OF THE MUSCLES.—*Number and General Arrangement. Modes of Attachment. Characteristic Property of Muscles. Muscles of the Head and Neck—Of the Trunk—Of the Upper Extremities—Of the Lower Extremities.*

151. The MUSCULAR SYSTEM is that by which animals perform all motion. The number of muscles in the human body is more than five hundred. In general they form about the skeleton two layers, distinguished as *superficial* and *deep-seated* muscles; yet in some parts there are three, four, five, and even six layers. (Fig. 49.) These layers of muscle constitute the firm "ruddy flesh" which is found everywhere beneath the skin.

FIG. 49.

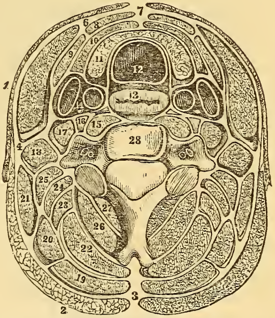


FIG. 49. A TRANSVERSE SECTION OF THE NECK. —The separate muscles, as they are arranged in layers, with their investing fascia, are well represented. 12, The trachea. 13, The œsophagus. 14, Carotid artery and jugular vein. 28, One of the bones of the spinal column. (The figures in the white space represent fascia; other figures, muscles.)

152. The muscles are usually attached to the bones, either directly or indirectly, by means of the inelastic but flexible tendons, which may be cord-like, either round or flattened, or membraniform, supporting the organs which they surround, and named *Aponeuroses* or *Fasciœ.*

153. The characteristic property of the muscles is *con-*

tractility; by means of certain stimulants, muscles *swell* and shorten themselves, so as to draw together any two points to which their ends are attached; as each muscle has its antagonist, when one shortens or contracts, the other relaxes. The muscles passing over the back of a joint are usually called *Extensors*, because they serve to extend the part beyond the joint, while those lying in front of the joint are, for the opposite reason, called *Flexors.* (Fig. 55.)

154. MUSCLES OF THE HEAD AND NECK.—By the contraction of the *Occipito-Frontalis* the eyebrows are elevated. The *Orbicularis Palpebrarum* closes the eyelids, and, by pressing back the ball of the eye, it also compresses the lachrymal gland and causes a flow of tears. The *Orbicularis Oris* closes the mouth and enables the lips to embrace any substance placed between them. It receives into its periphery the fibres of the surrounding muscles, which meet here as in a common centre. It enters largely into the diversified expressions of the countenance, and in no one respect exhibits more varied adaptation than in the performance on wind instruments. The *Masseter* and *Temporal* give motion to the lower jaw. The *Sterno-Cleido-Mastoid*, when both sides contract, draws the head forward or elevates the sternum. (Fig. 50.)

155. MUSCLES OF THE ANTERIOR PART OF THE TRUNK.—The *Pectoralis Major* draws the arm by the side and across the chest, and also draws the scapula forward. The *Serratus Magnus* elevates the ribs in inspiration. The *Obliquus Externus* and *Rectus Abdominalis* exert an equable pressure upon the organs contained in the abdominal cavity; when acting together they bend the body forward or elevate the hips; they also depress the ribs in respiration. When the muscles of but one side act, the body is twisted to that side. (Fig. 50.)

156. MUSCLES OF THE POSTERIOR PART OF THE TRUNK.—The *Trapezius, Rhomboideus Major* and *Minor* draw the scapula back toward the spine; the two latter draw the scapula upward toward the head and slightly backward; the former draws the head back and elevates the chin. The

Fig. 50.


OCCIPITO FRONTALIS
ORBICULARIS PALPEBRARUM
TEMPORAL
ORBICULARIS ORIS
MASSETER
STERNO-CLEIDO-MASTOID
FLEXOR CARPI RADIALIS
FLEXOR CARPI ULNARIS
FLEXOR DIGITORUM
BICEPS
TRICEPS
STERNUM
PECTORALIS MAJOR
DELTOID
RECTUS ABDOMINALIS
OBLIQUUS EXTERNUS
SERRATUS MAGNUS
EXTENSOR DIGITORUM
EXTENSOR CARPI RADIALIS
ANNULAR LIGAMENT
GLUTEI MUSCLES
RECTUS FEMORIS
SARTORIUS
ADDUCTOR MUSCLES
RECTUS FEMORIS
VASTUS EXTURNUS
BICEPS FEMORIS
GASTROCHNEMIUS
TENDO ACHILLIS
EXTENSOR DIGITORUM
ANNULAR LIGAMENT

Latissimus Dorsi draws the arm by the side and backward. The *Serratus Posticus Inferior* depresses the ribs in expiration.

Fig. 51.

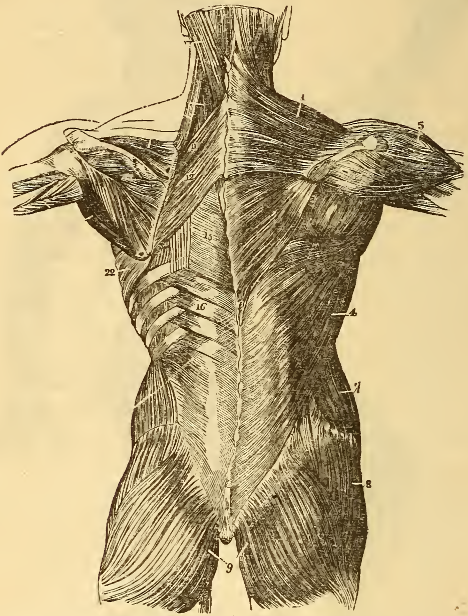


Fig. 51. The Dorsal Muscles.—The first, second and part of the third layer of muscles of the back. The first layer is shown on the right, and the second on the left side. 1, The trapezius muscle. 4, The latissimus dorsi muscle. 5, The deltoid muscle. 7, 8, The gluteus medius muscle. 9, The gluteus maximus muscle. 11, 12, The rhomboideus major and minor muscles. 16, The serratus posticus inferior muscle. 22, The serratus magnus muscle.

157. Muscles of the Upper Extremities.—The *Deltoid* raises the arm from the side of the body to a horizontal position. The *Biceps* flexes the fore-arm on the arm, as in preparing for striking a blow. The *Triceps* extends the fore-arm on the arm; it lies on the back of the humerus, and is

used in striking a blow. The *Flexor Carpi Radialis* passes under the annular ligament and bends the hand on the wrist. The *Flexor Carpi Ulnaris* bends the hand in the direction of the ulna. The *Flexor Digitorum* bends the fingers. The *Extensor Digitorum* extends the fingers. The *Extensor Carpi Radialis* extends the wrist on the fore-arm. (Fig. 50.)

158. Muscles of the Lower Extremities.—The *Glutei* give power of retaining the erect position. The *Sartorius* bends the lower extremities into the position assumed by the tailor at his work. The *Rectus Femoris, Vastus Externus* and *Vastus Internus* extend the leg on the thigh. The *Triceps Abductor Femoris* bends the thigh on the pelvis, rotates it outwardly and acts powerfully in bending the limbs inward. The *Biceps Femoris* forms the outer hamstring, assists in turning the leg outward, and also flexes it upon the thigh. The *Extensor Digitorum* splits into four tendons which pass under the annular ligament, and extend the four lesser toes and flex the foot. The *Peroneus Longus* extends the foot and inclines the sole obliquely forward. The *Gastrochnemius Externus* raises the body in walking, and extends the foot on the leg. The *Tendo-Achilles* (heel-cord) is formed by the conjoined tendons of the gastrochnemius externus and internus (and plantaris). (Fig. 50.)

§ **13.** Histology of the Muscles.—*Analysis of a Muscle. Sheaths of Muscles. Law of Muscular Contraction. Classes of Muscles. Tendons, Blood-vessels and Nerves.*

159. A Muscle is separable into bundles of fibres called *Fasciculi*, each bundle or fasciculus into smaller fibres (smaller fasciculi), each of the smaller fibres into a multitude of filaments or *fibrillæ* (fibrils), and each filament or fibrilla into cells arranged in a linear series. Hence, a single muscle is composed of some millions of these fibrillæ combined together, having the same point of attachment or *origin*, and concentrating in a tendon which is fixed to a movable part, or the point of *insertion*. (Figs. 7, 52, 53.)

160. Each muscle is invested by a membranous covering

of areolar tissue, named the *Perimys'ium;* from this, thin partitions pass inward between the large and small fasciculi, so that were it possible to remove the muscular substance there would remain a delicate areolar network of the exact shape of the muscle and its parts. Each elementary fibre or fasciculus is enclosed in a very thin, transparent, structureless *sheath,* called *Myolem'ma.* This sheath is entirely distinct from that of the areolar tissue; it isolates each ultimate fasciculus and probably gives off a sheath to each fibril.

Fig. 52.

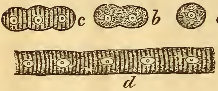


Fig. 52. Development of Striated Muscular Fibre from Cells.—*a,* Simple cell. *b,* A pair of cells fused together. *c,* Three cells fused and their contents assuming the striated character. *d,* A muscular fibre exhibiting its original composition of cells.

Observation.—Muscles contain bundles of varying size. These, whether fasciculi or filaments, may become diseased (inflammation). Such disease may abate either without or with decomposition, the formation of purulent matter (abscesses) in or between the muscles. In all such cases an early opening should be had to allow free exit for the purulent matter. The deeper the abscess, the more imperative an early free opening.

161. Muscles are of two classes, *Striated* and *Non-Striated.* The Striated are also called *Voluntary,* being, in their normal action, under the control of the will; the Non-Striated, *Involuntary,* acting independently of the will, as the heart, the stomach and the intestines. The latter are soft, pale, smooth, either roundish or flattened and indistinctly granulated, having no markings or striæ; the former are soft, yellowish, prismatic, and composed of quadrangular particles so arranged as to give transverse striæ.

162. The muscular law is that they shall *contract toward the centre.* To accomplish this there must be diversity of form, adapting them to different positions. Hence, muscular fibres are longitudinal, terminating at each extremity in a tendon, forming a *spindle-shaped* or *fusiform muscle;* disposed like the rays of a fan, converging to a tendinous point, a *radiate muscle;* converging to one side of a tendon running the

whole length of a muscle, as one side of the plume of a feather to its shaft, a *penniform muscle;* converging to both sides of the tendon like an entire feather, a *bi-penniform muscle;* or running in a circular direction, an *orbicular* or *sphincter muscle.* (Figs. 50, 53.)

Fig. 53.

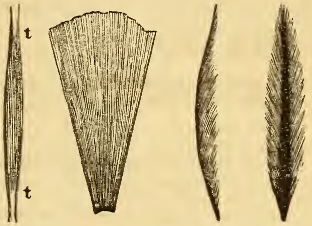


Fig. 53.—1, A Representation of the Direction and Arrangement of the Fibres in a fusiform or spindle-shaped muscle. 2, In a radiated muscle. 3, In a penniform muscle. 4, In a bi-penniform muscle. *t*, *t*, The tendons of a muscle.

163. Tendons are composed of the inelastic white-fibrous tissue, and possess great strength. The muscular fibres do not cease immediately, but intertwine with those of the tendons and these with those of the bone. The tendinous and muscular fibres are generally parallel, thus being straight in the sartorius and oblique in the penniform muscles. In passing over bones or other hard parts, they are protected by synovial bursæ.

Observation—Boils are peculiar abscesses between the muscles, immediately under the skin. Some cellular tissue loses its vitality, and constitutes what is called the "core." The most effective treatment is a very early (as soon as the boil commences) free incision to the bottom of the boil; then apply any warm, soft poultice.

164. The Blood-vessels do not enter the proper muscular substance, but everywhere abound in the areolar tissue by which the fibres are enveloped; hence, the nutriment necessary for the growth and repair of muscular tissue must be absorbed through the Myolemma.

165. The Nerves seem to occupy the same position as the blood-vessels in relation to the primitive fibres, and therefore must also exert their influence through the Myolemma. The nerves of the voluntary muscles are abundant, and chiefly of the *motor* class, or those which preside over motion, having nothing to do with sensation, and hence acting *from* the brain

7 *

and spinal cord to the muscles; while the nerves of the involuntary muscles are few and of the *sensory* class, or those which preside over sensation, having nothing to do with motion, hence conveying impressions to the brain and spinal cord. (Fig. 142.)

§ **14.** THE CHEMISTRY OF THE MUSCLES.—*Chemical Composition of Muscle. Chemical Changes attending Muscular Action. The Muscular Current.*

166. The chemical composition of muscular tissue cannot be precisely known because of the difficulty of isolating the fibres from the areolar tissue, blood-vessels and nerves blended with them. We give the analysis of Berzelius, by which it appears that less than twenty-three per cent. of ordinary meat is solid matter:

Proper muscular substance	15.80
Gelatin (firm areolar tissue)	1.90
Albumen and hæmatin	2.20
Phosphate of lime with albumen	.08
Alcoholic extracts with salts (lactates)	1.80
Watery extracts with salts	1.05
Water and loss	77.17
	100.00

Inosit, or *Muscle Sugar*, exists in the juice of flesh.

167. The proper muscular substance differs from simple fibrous tissue in not being resolved into gelatin by boiling. It contains a peculiar principle called *os'mazome;* this is colored, soluble in alcohol, and gives to broth its characteristic taste and smell.

168. Muscular action is accompanied by chemical changes due to the oxidation of muscular tissue. Quiescent muscle is neutral (neither acid nor alkaline) in chemical character, but muscle after repeated contractions is acid. Heat is evolved, both by chemical action and increased capillary activity, in proportion to the amount of exercise performed. The electrical current known as the "muscular current" is probably a result of chemical action. In the entire muscle its path

lies along the outside toward the tendons. The direction of the total current of the body is from the head downward.

Observation.—In friction or rubbing the body with the hand, the direction of the current should be followed; otherwise, irritation is produced rather than the soothing influence desired. This direction is of special importance to nurses and watchers in caring for the sick, particularly nervous patients. The effect of friction is sometimes improved by moistening the inside of the hand.

§ **15.** Physiology of the Muscles.—*Relative Uses of the Bones and Muscles. Important Functions of the Muscles. Exciting Agents of Muscular Contractility. Relation of the Will and the Muscular Sense to Muscular Action. The Muscular Sense as a Source of Enjoyment. Importance of Involuntary Movements—Of such Movements being sometimes Voluntary. Uses of Tendons. The Mechanical Powers as exhibited in Muscular Action—Levers—Pulley. Minute Muscles.*

169. To give a clear idea of the relative uses of the Muscles and Bones, we quote the comparison of another: "The Bones are to the body what the masts and spars are to the ship—they give support and the power of resistance; the Muscles are to the bones what ropes are to the masts and spars."

170. The Uses of the Muscles are manifold: they give the beautiful form and symmetry of the exterior of the body; enclose the cavities, and form a firm, defensive, but yielding wall in the trunk; invest and move the bones of the limbs; and give to some of the joints their principal protection. By means of the contractile property and various mechanical contrivances of muscular fibres, the heart pulsates; the blood circulates; respiration is carried on; the conduits of the glands urge on their fluids; and mechanical aid is afforded in the various processes of preparing nutriment for the system. We are indebted to the same for our power of locomotion; for our ability to engage in the manifold employments of life; to enjoy its pastimes; and to hold communication with our fellow-men by speech, gesture and the varied expressions of the human countenance.

171. The "Vis Musculosa," or contractility of the muscle, is excited on the application of certain stimuli; these may

be *Mechanical,* as the touch of a sharp instrument; *Chemical,* as acids and alkalies; *Electrical,* as in shocks; and *Vital,* originating in, or acting through, the nervous system: it is by means of the latter that muscular fibre is most frequently called into action.

172. The VOLUNTARY MUSCLES in their normal condition, both in their contraction and relaxation, are subject to the control of the *Will* and the guidance of the *Muscular Sense;* the will determines an act, and the muscular sense enables us to judge of the effort necessary to its performance. By the aid of the *Muscular Sense,* sometimes with conscious volition and sometimes without it, we regulate the force employed in all the movements of the body, as lifting weights, balancing the body in standing or locomotion, moving the arms in prehensile or manipulating acts, and exercising the vocal organs. The feats of the rope-dancer and trained gymnast are largely due to the cultivation of this sense. The exercise of the muscular sense is a source of positive enjoyment. The person who walks with an elastic step, holding the body in easy equilibrium, experiences a *sensible* pleasure unknown to him who moves with shuffling gait and apparent distrust of the integrity of his muscles; so in dancing, gymnastic and skating exercises, if attention is given to elegance of attitude and *harmony of motion,* there is experienced a pleasure quite distinct from that gained by the quickened activities, and which is attributable to the muscular sense.

173. The INVOLUNTARY MUSCLES perform their functions wholly independent of the will, and are essential to the action of the heart, the digestive organs, the respiratory apparatus, and various ducts, blood-vessels and lymphatics. The Divine Builder has wisely ordered that these vital operations should not be subject to the control of the individual. Again, there are certain operations *generally* entrusted to the involuntary muscles that may be temporarily controlled when occasion requires, as in respiration; were these movements never under the control of the will, we should be unable to use to any advantage the vocal apparatus either in speech or singing, and

were we compelled to breathe at perfectly regular intervals, it would be exceedingly difficult to attend to the daily duties of life.

174. TENDONS serve to convey the contractile power of muscles to the bones; they are, in themselves, passive organs possessing no contractility. In them the evidence of care and skillful arrangement is beautifully exhibited. Wherever muscular action is wanted, and the presence of muscle would be inconvenient or mar the harmony of proportion, or where great strength is needed, there we find the small, dense, conducting tendons; the slits in the short tendons of the second joint to allow the long tendons from the muscles of the forearm to pass through to the last bones of the fingers afford the best conceivable arrangement for compactness, delicacy, beauty and utility. (Fig. 54.)

FIG. 54.

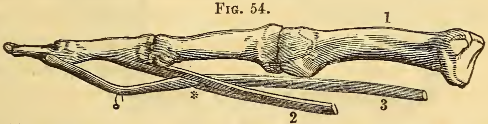


FIG. 54. METACARPAL AND PHALANGEAL BONES OF THE FINGERS, WITH THEIR TENDONS AND LIGAMENTS.—1, Metacarpal bone. 2, Tendon of the superficial flexor. 3, Tendon of the deep flexor, passing through a perforation (*) of the superficial flexor.

175. *In the action of the muscles upon the bones, we have examples of the three kinds of Levers** treated of in mechanics. *In the first kind,* the fulcrum is between the power and the weight, as in scales, scissors, etc.; *in the second,* the weight is between the power and the fulcrum, as is seen in moving the common wheelbarrow or a door; *in the third,* the power is between the weight and the fulcrum, as in using the fire-tongs. In the body the bones are the levers; the parts

* A lever is a rod of wood, metal or other substance, movable in one plane about a supported point in the rod, called a *fulcrum.* The resistance to be overcome is called the *weight,* and the force used in overcoming the resistance is called the *power.* The three kinds of lever are distinguished from each other by the relative position of the power, weight and fulcrum.

attached, the weights; and the muscles, the powers. The fulcrums are the joints, or extremity of the limbs in contact with the ground or other resisting substance.

176. *The first kind of lever is illustrated* in the adjustment and movement of the skull upon the first vertebra; the hinge-joint is the fulcrum; the excess in gravity of the parts of the head in front of the joint over the parts behind it is the weight; and the muscles extending from the spine to the cranium are the power. (Fig. 50.)

Fig. 55.

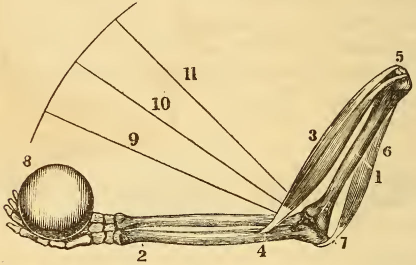


Fig. 55. Diagram of the Third Kind of Lever.—1, Humerus. 2, Ulna. 3, Biceps muscle. 4, Its attachment to the ulna. 5, Its attachment to the humerus. 5, Triceps muscle. 7, Its tendon. 8, The ball to be moved. 9, 10, 11, Direction of the ulna and ball when the biceps (3) muscle contracts. When the triceps (6) muscle contracts, the fore-arm is extended.

177. *The second kind of lever is illustrated* in the foot. When resting on the ground, with the heel raised, the fulcrum is at the ball of the great toe; the weight is the body transmitted through the large bone of the leg; and the power is in the muscles of the calf of the leg (Gastrocnemii) acting through the tendon of Achilles. (Fig. 50.)

178. *The third kind of lever* is most used in animal mechanics; as in raising the lower jaw, in raising the shoulder and collar-bone, and in the flexion of all the joints of the limbs. A familiar example is the elbow. The fulcrum is at the joint; the weight is the fore-arm and hand; and the power is in the biceps and brachial muscles. (Figs. 50, 55.)

179. *The principle of the pulley* is also used in the arrangement of the muscles, though less frequently than the lever. The annular ligaments which confine the tendons at the wrist and at the ankle act as pulleys. A marked example is seen in one of the muscles that pull down the lower jaw, called the *digastric* muscle. Another beautiful example is furnished by the trochlear muscle of the eye (Figs. 56, 170).

180. We have noticed only the larger of the exterior layer of muscles. The limits of this work will not allow a full view of the exquisite beauty beneath; the layers are of various sizes and forms, and crossing each other in every direction, yet the millions of fibres and multiplied millions of cells perform their assigned work in perfect harmony, not one interfering with the action of another.

Fig. 56.

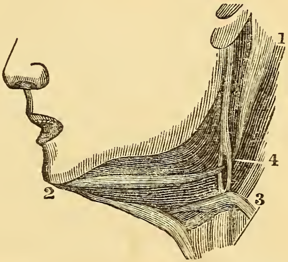


Fig. 56. Pulley Arrangement of a Muscle. —1, Digastric muscle attached to the mastoid process of the temporal bone behind the ear. 2, Its attachment to the lower jaw. 3, Hyoid bone. 4, The pulley arrangement of the digastric and stylo-hyoid muscles.

181. Infinite mechanical skill is still more wonderfully shown in the nice adjustment and accurate movements of the *minute muscles*, as those of the tongue, and the yet finer muscles of the eye and the drum of the ear, too small to be seen by the naked eye.

182. Everywhere the muscular force is one and the same, but its applications are innumerable; the instruments are constructed upon the same plan, but infinitely varied in form, size and arrangement, yet made with the greatest simplicity for effecting each its particular purpose.

> "In human works, though labored on with pain,
> A thousand movements scarce one purpose gain;
> In God's, *one single* can its ends produce,
> Yet serves to *second, too, some other use*."

§ **16.** Hygiene of the Muscles.—*Requirements necessary to maintain a Healthy Condition of Muscle. Importance of Freedom from Compression—Of Exercise. Conditions to be observed in Muscular Exercise. Exercise sometimes Injurious. Effect of Mental Stimulus. Regard necessary to the Age and Health—Position of the Body—Proper Muscular Tension. Education of the Muscles.*

183. Since so much of our happiness and usefulness in life depends upon *healthy muscles*, it is of great importance that we seek to understand the laws upon which their normal action depends. The first and great essential is, that *the muscles should be abundantly supplied with pure blood.* A pure state of the blood requires that the digestive apparatus should be in a healthy condition; that the vital organs should have ample volume; that the lungs should be plentifully supplied with pure air; that the skin should be kept warm by proper clothing and clean by bathing, and that it should be acted upon by *air* and *sunlight.* It is also of primary importance that there be *free circulation* of the blood, which may be secured by *freedom from compression* and by *regular and judicious exercise.*

184. *Freedom from compression* is requisite to free circulation, for even a slight pressure upon the delicate, yielding blood-vessels checks the flow, thus preventing the necessary deposit of materials required by the waste of the system.

185. *Free circulation, and, consequently, muscular power, is increased by proper exercise, and decreased by inactivity.* It is a general law of the system that the action and power of an organ are, within a certain limit, commensurate with the demand made upon them—a law which holds good in the muscular apparatus. When the muscles are exercised, the flow of blood in the arteries and veins is increased, hence the muscular fibre increases in size and acts with greater force; while, on the contrary, the muscle that is little used receives little nutriment from the sluggish blood, and decreases in size and power.

Illustration.—The muscles of the blacksmith increase in size and become firm and hard; those of the student, if not used in gymnastics or otherwise, decrease in size and become soft and less firm.

186. *Relaxation must follow contraction, or rest must follow exercise.* Exercise too long continued produces exhaustion, and in the exercise of exhausted muscle the loss of material exceeds the deposit; also long-continued tension enfeebles, and at length destroys, the contractile property.

Illustration.—The effect of continued tension is seen in the restlessness of children at school after sitting for a time in one position. The necessity of frequent recesses is founded upon the organic law that relaxation of muscle must follow contraction. The younger and feebler the pupils, the greater is this necessity.

187. *Change of employment often affords the required rest,* as it brings into action a new set of muscles; hence the person of sedentary occupation is rested by general muscular exercise, while the person of active occupation is rested by that of a sedentary character.

Illustration.—The needlewoman exhausts the muscles of the back and arm; a brisk walk or some active household employment affords rest.

188. *The muscles should be gradually called into action,* for while in action they require more blood and nervous fluid than when at rest, and these fluids are gradually increased. In an alarm of fire, never start "on the run," but "make haste slowly" in the first instance, and then gradually increase your speed.

189. *The muscles should be rested gradually after vigorous exercise.* If a person has made great muscular exertion, instead of sitting down immediately to rest, he should continue to exercise *moderately* for a short time and avoid sudden *cooling* in a current of air; additional clothing is often needed. The soreness of muscles which have been severely exercised is often prevented by bathing and thorough rubbing, followed by moderate exercise.

190. *Exercise should be regular and frequent.* The system needs this means of invigoration as regularly as it needs new supplies of food. To devote a few days to the proper action of the muscles, and then spend a day inactively, is as incorrect as to take a proper amount of food for a time and then to withdraw the supply for a season.

191. *Every part of the muscular system should have its appropriate share of exercise.* Farming and domestic employments are superior as vocations in respect to giving all the muscles their due proportion of action. Where the daily occupation exercises but a part of the muscles, it should be followed by some employment or recreation which will bring the others into use.

192. *The amount of exercise should be adapted to the age and strength of the individual.* In youth a portion of the vital or nervous energy of the system is expended upon the *growth* of the organs of the body; consequently, severe labor or exercise is injurious.

Observation.—In the campaigns of Napoleon Bonaparte his army was frequently recruited by mere boys. He complained to the French government because he was not supplied with mature men, as the youths could not endure the exertions of forced marches.

193. *The proper time for exercise should be observed.* As a general rule, the morning is a better time for exercise than the evening; the powers of the system are greatest at that time. Severe exercise should be avoided immediately before or after a meal; the vigor of the system is then required for the digestive functions. The same rule should be observed regarding mental toil, as the powers of the system are then concentrated upon the brain.

194. *The mind exerts a great influence upon the tone and contractile energy of the muscles.* Muscular exercise will be attended with much less fatigue when the muscles act under a healthy mental stimulus. This we see illustrated in the ordinary vocations of life; if the mind has some incentive, the tiresomeness of labor or exercise is greatly diminished.

> "He chooses best whose labor entertains
> His vacant fancy most; the toil you *hate*
> Fatigues you soon, and scarce improves your limbs."

The effect of the mind upon the muscles is seen in the spiritless aspect of many of our boarding-school processions when a walk is taken merely for exercise, with no other object in view.

195. *The amount of exercise should be adapted to the health of the individual.* This direction is of essential importance, for what gives *vigor* to one may bring *weakness* to another. A walk which would invigorate one in health will quite exhaust a feebler person; hence, the *measure of strength* must be the *measure of exercise.*

Observation 1.—*In diseases producing great muscular exhaustion particular care and discretion are necessary regarding exercise.* In scarlet fever, typhoid diseases, etc., the muscular debility is very great, and any muscular exertion that exhausts, such as moving the patient home when he has sickened abroad, or undue exercise during convalescence, is almost sure to result injuriously, if not fatally. Exercise should be moderate, made pleasant, and followed with proper intervals of rest, and *never* at the discretion of one who is ignorant of the peculiar state of the system.

2.—*In chronic diseases of the digestive organs, lungs and nervous system, well-directed and persistent exercise of the muscles is essential to recovery.* In these ailments the exertion of all the muscles repeated frequently is attended with the most compensatory results. Moderation is necessary at first, but the exercise should be increased in intensity and duration. The aversion of the patient to exercise is often very great, but it should, nevertheless, be persistently taken in the same spirit in which he would perform any other part of the lifework entrusted to him. Making it a *business* to perform the labor necessary to recovery and entering into it with the *heart* and *will*, gives the healthy tone and stimulus so important in securing the most beneficial results.

Illustration.—A patient who had suffered long from a combination of chronic ills, which had baffled the skill of several physicians, in extreme weakness adopted a systematic plan of exercise, commencing with but two or three steps at a time and adding a step or two each day, till in six months' time she walked regularly three miles a day.

196. *The muscles require an erect position of the body both in standing and in sitting.* A person can stand longer, walk farther, and perform more labor in an erect position than when stooping, since fewer muscles are then in a state of tension, and, consequently, less draught is made on the nervous system.

197. It is important that the muscles of the child should receive due attention, that the shoulders may be thrown back and the chest become broad and full. Even when an adult has contracted the habit of stooping and has become round-

shouldered, it can be measurably, and generally wholly, corrected by moderate and repeated efforts to bring the shoulders into proper position. This deformity should receive attention in our schools. It may be remedied as well by persistent effort on the part of a kind instructor as under the stern military drill-sergeant, who never fails to secure the erect attitude in his raw recruits. In furnishing schoolrooms with desks, care should be taken that they be of suffi-

Fig. 57. Fig. 58.

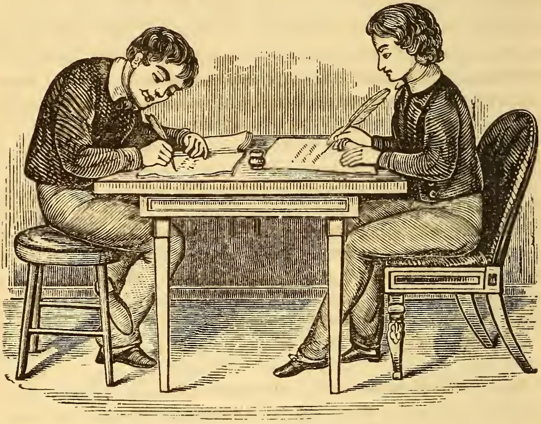


Fig. 57 represents an Improper, but not an unusual, position when writing.
Fig. 58 represents a Proper position when writing.

cient height to allow the proper attitude when pupils are using their books or the pen. This is not only essential to health, but to beauty and symmetry of form. (Figs. 57, 58.)

Observation.—A simple test of the erect position is to stand with the back against the wall of a room, with the heels, elbows and back of the head touching the wall. The effort required to do this will show the amount of departure from the true attitude.

198. *A slight relaxation of the muscles tends to prevent their exhaustion.* In walking, dancing and most of the mechanical

employments the fatigue will be less and the movements more graceful if the muscles are slightly relaxed. The same condition diminishes the jar of cars or coaches.

199. *The muscles require to be educated or trained.* Frequent and systematic use of the muscles at proper intervals is necessary to effective action. This education must be continued till not only each muscle, but every fibre of the muscle, is fully under the control of the will. In this way persons become skillful in every employment. The power of giving different intonations in reading, speaking and singing, the rapid movements in penmanship and in mechanical and agricultural employments, depend, in a great measure, upon the education of the muscles. An individual with trained muscles will perform a given amount of labor with less fatigue and waste to the system than one whose muscles are untrained.

Observation.—It is exceedingly important that correct movements be insisted upon at the *commencement* of any muscular training, as it is very difficult to change a movement which has been long practiced. If a child holds his pen improperly during his early lessons, he will probably never become an easy and elegant writer.

§ **17.** COMPARATIVE MYOLOGY.—*Compare Muscles of other Mammals with those of Man. Muscles of Birds—Of Reptiles—Of Amphibia—Of Fishes.*

200. The muscles of all *Mammals* in their general plan resemble those of Man, the modifications in number, form, position and relative size being only such as adapt them to the habits and necessities of the particular species. The color of the muscle is deepest in the Carnivora (flesh-eaters), and palest in the Rodentia (gnawers).

201. The muscular system of *Birds* is remarkable for the distinctness and density of their fasciculi, for the deep-red color of those employed in vigorous action and their marked separation from the tendons, which are of a pearly-white color and have a peculiar tendency to ossification. This high development results from the rapid circulation of warm, rich, highly-oxygenated blood through the extent of the respira-

tory system. The energy of the muscular contraction in this class is in the ratio of the activity of the vital functions. In *Birds* the muscles are varied to meet the habits, wants and condition of the several species and orders.

Fig. 59.

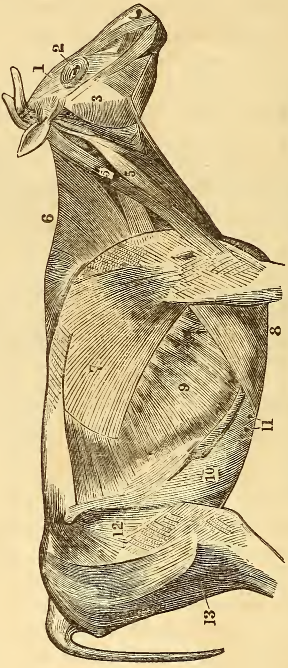


Fig. 59. Superficial Muscles of a Cow.—1, Occipito-Frontalis. 2, Orbicularis Palpæbrarum. 3, Masseter. 5, Sterno-cleido-Mastoid. 6, Trapezius. 7, Latissimus Dorsi. 8, Pectoralis. 9, 10, External and internal oblique muscle. 11, Opening of the mammary artery and vein (milk-veins). 12, Gluteii. 13, Rectus Femoris muscle.

202. The muscles of the *Reptiles* are always pale in color, and the fibres are tenacious of their contractility; the energy of their contraction in some instances and on some occasions is great, but it cannot be continuously exercised, such power

being soon exhausted. The form, size and relative number of the muscles are as various as in mammals and birds.

In *Reptiles* the muscular system of the trunk reaches its maximum development in Serpents, and its minimum devel-

Fig. 60.

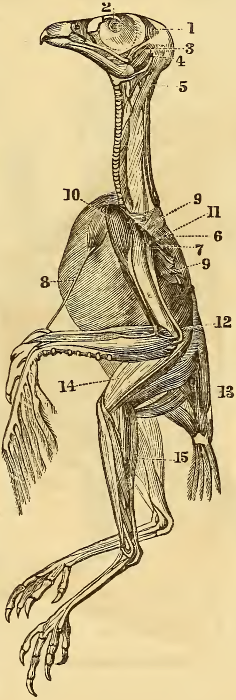


Fig. 60. Superficial Muscles of a Hawk.—1, Occipito-Frontalis. 2, Orbicularis Palpæbrarum. 3, Temporal. 4, Masseter. 5, Sterno-cleido-Mastoid. 6, Trapezius. 7, Latissimus Dorsi. 8, Pectoralis. 9, Deltoid. 10, Biceps. 11, Triceps. 12, Gluteii. 13, Levator Caudæ. 14, Rectus Femoris. 15, Gastrocnemius muscle.

opment in the Tortoise. The mandibular development is generally large, while that of the limbs is comparatively small or entirely wanting.

203. In the *Amphibians*, portions of the *Myocom'mas* or flakes become grouped into three longitudinal muscles corresponding to the "spinalis dorsi," "longissimus dorsi," and sacrolumbalis of Mammals.

204. In *Fishes* there is a modification of the active motor organs, and a marked deviation from the fundamental vertebral type. The chief masses of the muscular system are disposed on each side of the trunk in a series of vertical plates or *flakes*, corresponding in number to the vertebræ. Each lateral flake (myocomma) is attached by its inner border to the osseous and fibrous parts of the corresponding segment of the skeleton within; by its outer border, to the skin;

Fig. 61.

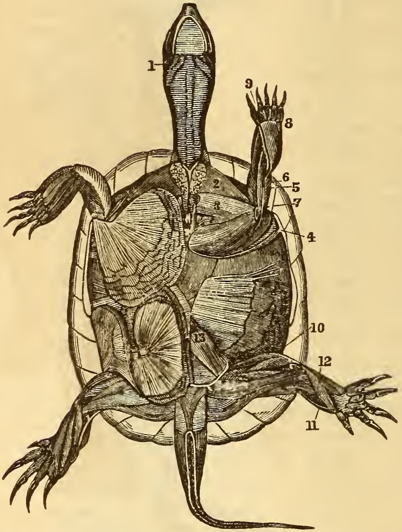


Fig. 61. Muscles of the Tortoise.—1, Digastricus. 2, 3, Deltoides. 4, Serratus Magnus. 5, 6, Triceps Brachii. 7, Biceps Brachii. 8, Ulnaris Internus. 9, Flexores Digitorum. 10, Sartorius. 11, 12, Gastrocnemius. 13, Triceps Adductor.

and by its fore and hind surfaces, to the septum between it and the contiguous myocommas or flakes. The gelatinous tissue of these septa is dissolved by boiling, and the muscular segments or plates are then easily separated, as we find in carving fish for the table. Each flake is arranged in a zigzag manner. The muscular tissue of fishes is usually colorless, sometimes it is opaline or yellowish, but it is white when boiled.

Fig. 62.

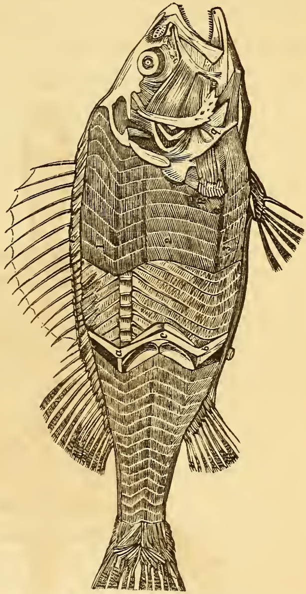


Fig. 62. Muscles of the Fish.—*a*, *b*, *c*, and 1, 2, 3, The zigzag arrangement of the myocomma.

205. All movement is attended and produced by contraction of muscles; and in a very large portion of the four lower sub-kingdoms of animals, composing the Invertebrata, the muscles are so minute that they cannot be so well demonstrated, yet it is probably true that in structure, in appointment and in varied use they may be as complete and wonderful as those of the Vertebrata. Among all domestic animals, as the horse, ox and fowl, the same hygienic laws relative to protection, food, air, light and exercise are equally applicable as to man.

ANALYTIC EXAMINATION.

Chapter V.—The Muscles.

§ **12.** *Anatomy of the Muscles.*—151. Define Muscular System. Give the number of muscles. How distinguished? 152. Give the attachment of the muscles. 153. State their characteristic property. Define Extensors and Flexors. 154. State the office of the Occipito-Frontalis; of the Orbicularis Palpæbrarum; of the Orbicularis Oris; of the Masseter and Temporal; of the Sterno-Cleido-Mastoid. 155. Of the Pectoralis Major; of the Serratus Magnus; of the Obliquus Externus and Rectus Abdominalis. 156. Of the Trapezius, Rhomboideus Major and Minor; of the Latissimus Dorsi; of the Serratus Posticus Inferior. 157. Of the Deltoid; of the Biceps; of the Triceps; of the Flexor Carpi Radialis; of the Flexor Carpi Ulnaris; of the Flexor Digitorum; of the Extensor Digitorum; of the Extensor Carpi Radialis. 158. Describe the Glutei; Sartorius; Rectus Femoris; Vastus Externus; Vastus Internus; Triceps Abductor Femoris; Biceps Femoris; Extensor Digitorum; Peroneus Longus; Gastrocnemius Externus; Tendo-Achilles.

§ **13.** *Histology of the Muscles.*—159. Into what is a Muscle separable? 160. By what is each muscle invested? What is Myolemma? Observation. 161. Name and describe the classes of muscles. 162. State the muscular law. Describe the different forms of muscles. 163. Describe the Tendons. 164. Where do you find the blood-vessels of the muscles? 165. What position do the Nerves occupy? What is said of the different classes of the nerves?

§ **14.** *Chemistry of the Muscles.*—166. What is said of the chemical composition of the muscles? Muscle sugar is where found? 167. How does proper muscular substance differ from simple fibrous tissue? 168. Name some of the chemical changes attending muscular action. What is said of the "muscular current"? Observation.

§ **15.** *Physiology of the Muscles.*—169. State the relative uses of bones and muscles. 170. Name the uses of the muscles. 171. How is contractility excited? 172. To what are the Voluntary muscles subject? Of what aid the muscular sense? What is said of the exercise of this muscular sense? 173. What are the Involuntary muscles? What involuntary muscles are somewhat under the control of the Will? Of what advantage this? 174. State the office of the Tendons. Do they possess contractility? In what respect do you see in them an exhibition of care and skill? 175. Where do we have examples of the different kinds of Levers? Define a Lever, and name its kinds. Explain each kind. 176. Where are the principles of the first kind illustrated? 177. Where those of the second? 178. Of the third? 179. Where does the pulley find illustration? 180. What is said of the different layers? 181. In what is mechanical skill shown? 182. Speak of muscular force.

§ **16.** *Hygiene of the Muscles.*—183. What advantage in possessing healthy muscles? Name the first essential. What does a pure state of the blood require? 184. Why should the muscles not be compressed? 185. How does exercise promote the health and growth of muscles? Illustration. 186. State the relation of relaxation to contraction. Illustration. 187. Give a reason for a change of employment. Illustration. 188. How should the muscles be called into action? 189. How rested? 190. How should exercise be taken? 191. What kind of exercise? 192. To what should the amount of exercise be adapted? Observation. 193. State the proper time for exercise. 194. Mention the influence of the mind on the muscles. 195. What should be taken into consideration as to the amount of exercise? In what diseases are great care and discretion necessary as regards exercise? What is said of the exercise of the muscles in chronic diseases of the digestive organs? What is important to secure beneficial results? Observation. 196. Why do the muscles require erect positions of the body? 197. What attention should be given to children and youth? What care in furnishing school-rooms? Observation.

200. Why relaxation of muscles necessary in walking, jumping, etc.? 201. State and illustrate the influence of education. Observation.

§ **17.** *Comparative Myology.*—202. What is said of the muscles of Mammals? Of their color? 203. For what is the muscular system of Birds remarkable? 204. Speak of the muscles of Reptiles. 205. Describe the muscles of Amphibians. 206. What modification of muscles in Fishes? What color? 207. What is said of the minuteness of the muscles in some animals? What of the application of hygienic laws?

UNIFIC REVIEW.

[Compare 151, 152 with 159, 160, 162 and 200–205.]

What is the structure of the muscles? State their relation to the bones. Compare the muscles of man with those of birds, reptiles, etc.

[Compare 163 with 18.]

Where do you find the white fibrous and muscular tissues closely related?

[Compare 164 with 341.]

How are the muscles nourished?

[Compare 165 with 394, 402, 403 and 420.]

State the connection between the muscular and nervous systems.

[Compare 166 with 43–46.]

Of what are muscles composed?

[Compare 184 with 329 and 381.]

State the evil results of compression of the muscles.

[Compare 185 with 330 and 441.]

What is the influence of exercise on circulation and muscular power? What is the effect of a want of it on the nervous system?

[Compare 186 with 192, 193 and 261.]

In taking exercise, what caution as to age, time, amount, etc.?

Fig. 63.

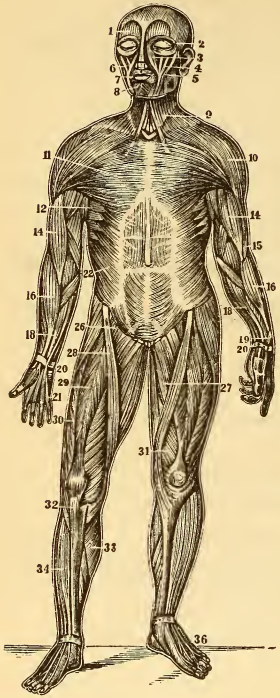


Fig. 64.

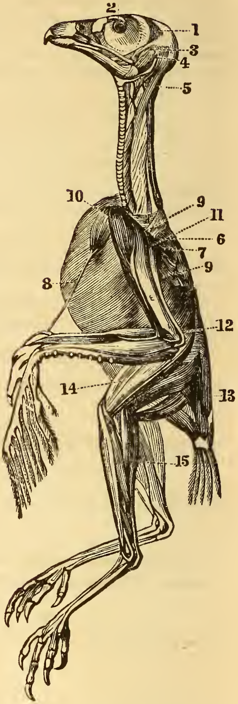


Fig. 63. A Front View of the Muscles.—1, 2, 3, 4, 5, 6, 7, 8, Muscles of the head and face. 9, Muscles of the neck. 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, Muscles of upper extremities. 22, Muscles of the body. 26, 27, 28, 29, 30, 31, 32, 33, 34, 36, Muscles of the lower extremities.

Fig. 64. Superficial Muscles of a Hawk.—1, Occipito-Frontalis. 2, Orbicularis Palpæbrarum. 3, Temporal. 4, Masseter. 5, Sterno-cleido-Mastoid. 6, Trapezius. 7, Latissimus Dorsi. 8, Pectoralis. 9, Deltoid. 10, Biceps. 11, Triceps. 12, Gluteii. 13, Levator Caudæ. 14, Rectus Femoris. 15, Gastrocnemius muscle.

SYNTHETIC TOPICAL REVIEW.

Topics	Section	Chapter
Number and general arrangement, Modes of attachment, Characteristic property, Head and Neck, of, Trunk, " anterior part of, " " posterior part of, Upper Extremities, Lower "	§ 12. *Anatomy of.*	Chap. V. *The Muscles.*
Analysis, Sheaths, Classes of, Consequent forms, Tendons, Blood-vessels, Nerves.	§ 13. *Histology of.*	
Chemical composition, Chemical changes attending muscular action, Muscular current.	§ 14. *Chemistry of.*	
Relative uses of bones and muscles, Important functions, Exciting agents of contractility, Voluntary, Relation of muscular sense, Importance of involuntary movements, Importance of such movements being sometimes voluntary, Tendons, Lever, Pulley, Minute.	§ 15. *Physiology of.*	
Healthy condition, Freedom from compression, Inactivity, influence of, Exercise, " " conditions to be observed, Mental stimulus, effect of, Age and health, regard for, Position of the body, Proper tension, Education, influence of.	§ 16. *Hygiene of.*	
Mammals, Birds, Reptiles, Amphibians, Fishes, Invertebrata.	§ 17. *Comparative Myology.*	

Give the Anatomy, the Histology, the Chemistry, the Physiology, the Hygiene, Human and Comparative, of the Muscles.

DIVISION III.

THE NUTRITIVE APPARATUS.

206. In the mastication and deglutition of food, in its conversion into fluids, in its circulation in all parts of the system, in its assimilation into the various tissues and organs of the body, in its disassimilation and in the excretion of useless matter,—in a word, in the building up and repairing of the system, from the earliest period of embryo life to the last moment of earthly existence, certain organs are used, which together may be termed the Nutritive Apparatus, including the *Digestive*, the *Absorptive*, the *Circulatory*, the *Assimilatory* and the *Respiratory* organs.

CHAPTER VI.

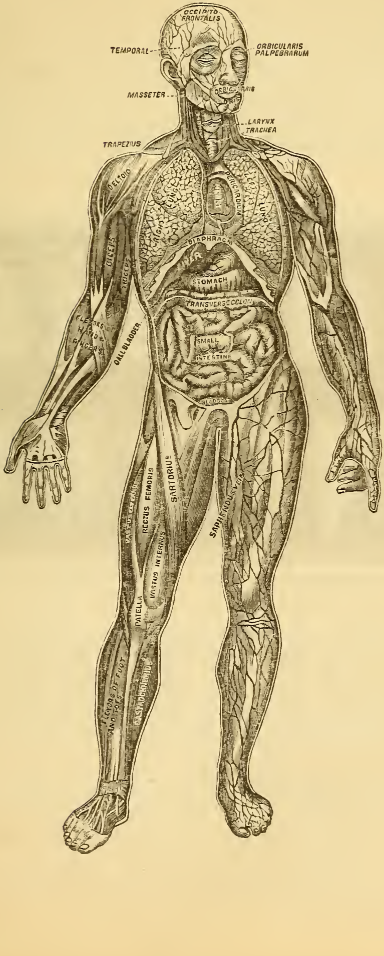
THE DIGESTIVE ORGANS.

§ **18.** Anatomy of the Digestive Organs.—*Anatomy of the Mouth —The Teeth—The Salivary Glands—The Pharynx—The Œsophagus —The Stomach—The Intestines—The Liver—The Pancreas—The Spleen.*

207. The Digestive Organs include the *Mouth, Teeth, Salivary Glands, Palate, Pharynx, Œsophagus, Stomach, Intestines, Liver, Pancreas* and *Spleen.*

208. The Mouth is the space bounded by the lips in front, the soft palate behind, the hard palate above and the floor below, upon which rests the tongue. (Fig. 66.)

Fig. 64.


OCCIPITO FRONTALIS
TEMPORAL
ORBICULARIS PALPEBRARUM
MASSETER
LARYNX
TRACHEA
TRAPEZIUS
DELTOID
PERICARDIUM
DIAPHRAGM
STOMACH
TRANSVERSE COLON
SMALL INTESTINE
GALLBLADDER
SARTORIUS
RECTUS FEMORIS
VASTUS INTERNUS
PATELLA

209. The TEETH are attached to the upper and the lower jaw-bone by means of bony sockets called *alve'olar* processes. The attachment is strengthened by the fibrous, fleshy structure of the gums. Each tooth has two parts, the *crown* and the *root.* The crown is that part which protrudes from the jaw-bone and gum, and is covered by the enamel; the root or fang is that part contained in the socket of the jaw, and the slightly-constricted portion clasped by the gums is the *neck.*

FIG. 65.

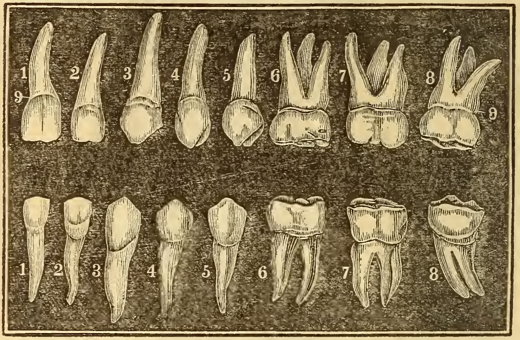


FIG. 65 REPRESENTS THE ADULT TEETH.—1, 2, The cutting teeth (incisors). 3, Eye-tooth (cuspid). 4, 5, Small grinders (bi-cuspids). 6, 7, 8, Grinders (molars). 9, 9, Neck of the tooth.

210. The first set of teeth appearing in infancy is called *temporary,* or the milk teeth. They are twenty in number, ten in each jaw. Between six and fourteen years of age they are replaced by the second set, called *permanent* teeth, numbering thirty-two, sixteen in each jaw. The four front teeth in each jaw are called *Incisors* (cutting teeth). The next tooth on each side the *Cuspid* (eye-tooth in the upper jaw and stomach tooth in the lower), the next two, *Bi-cuspids* (small grinders), the next two *Molars* (grinders), situated behind the other teeth. The last molars are the *dens sapientiæ* or "wisdom teeth," smaller than their fellows, late in their development

and early in their decay. The incisors, cuspids and bi-cuspids have each but one root; the molars of the upper jaw have three roots, those of the lower jaw two roots. (Fig. 65.)

211. A GLAND consists of a tube or series of tubes of *basement membrane* with nucleated cells, invested externally with a fibrous layer, in which are distributed blood-vessels from which the glands elaborate their secretion. The *Salivary Glands* consist of three pairs, the *Parot'id,** the *Submax'illary* † and the *Subling'ual.* ‡

FIG. 66.

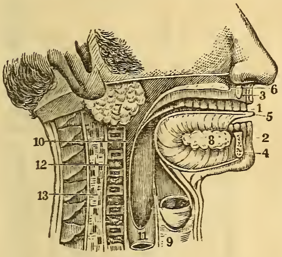


FIG. 67.

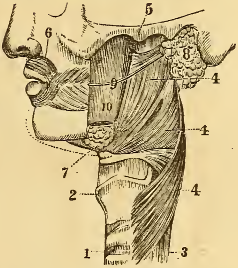


FIG. 66. THE MOUTH AND NECK LAID OPEN.—1, The teeth. 3, 4, Upper and lower jaws. 5, The tongue. 7, Parotid gland. 8, Sublingual gland. 9, Trachea (wind-pipe). 10, 11, Œsophagus (gullet). 12, Spinal column. 13, Spinal cord.

FIG. 67. A SIDE VIEW OF FACE.—1, 2, Trachea. 3, Œsophagus. 7, Submaxillary. 8, Parotid gland. 9, Duct from the Parotid gland. 4, 4, 4, 5, 6, Muscles.

The PAROTID GLAND, the largest, is situated in front of the external ear, and behind the angle of the jaw. The SUBMAXILLARY GLAND is situated within the lower jaw anterior to its angle. The SUBLINGUAL GLAND is elongated and flattened, and situated beneath the mucous membrane of the floor of the mouth. Ducts from these glands open into the mouth. (Figs. 66, 67.)

Observation.—The "mumps" is a disease of the parotid gland, and the swelling under the tongue called the "frog" a disease of the sublingual gland.

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* Gr., *para*, near, and *ous*, ear. † Lat., *sub*, under, *maxilla*, jaw-bone, ‡ Lat., *sub*, under, and *lingua*, the tongue.

212. The PHARYNX or throat is the funnel-like cavity about four inches in length extending from the base of the skull to the top of the fifth cervical vertebra, where it becomes continuous with the œsophagus.

213. The ŒSOPHAGUS is a large membranous tube, extending from the pharynx to the stomach. It lies behind the trachea, the heart and the lungs, and passes through the diaphragm. (Figs. 66, 67.)

214. The STOMACH is a somewhat pear-shaped dilatation of the alimentary canal. When moderately filled, it measures twelve inches in length by four inches in diameter. It has two openings, one connected with the œsophagus, called the *car'-diac* orifice, the other connected with the upper portion of the small intestine, called the *py-lor'ic* orifice. (Fig. 68.)

FIG. 68.

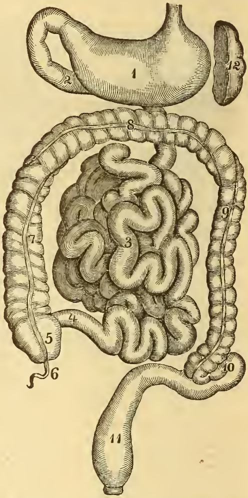

FIG. 68. THE STOMACH AND INTESTINES.—1, Stomach. 2, Duodenum. 3, Small intestine. 4, Termination of the ileum. 5, Cœcum. 6, Vermiform appendix. 7, Ascending colon. 8, Transverse colon. 9, Descending colon. 10, Sigmoid flexure of the colon. 11, Rectum. 12, Spleen.

215. The INTESTINES are divided into the *Small* and the *Large* intestines. The small intestine is about twenty-five feet in length, and divided into three parts, the *Duode'num*, the *Jeju'num* and the *Il'eum*. DUODENUM signifies *twelve*, and this part is so called because its length is about twelve fingers' breadth, or ten inches; JEJUNUM signifies *fasting*, the food passing quickly through this portion, leaving it empty; ILEUM, *twisted*, is so named from its numerous coils or convolutions. (Fig. 68.)

216. The large intestine, about five feet in length, is also

divided into three parts, the *Cœcum*, the *Colon* and the *Rectum.* The Cœcum is so called from its forming a *blind pouch* perforated at one end only; the Colon, because the excrements are arrested for a considerable time in its folds; and the Rectum, from its *straight* course.

Attached to the extremity of the cœcum is the *appendix vermiformis*, a worm-shaped tube about four inches long and the size of a goose-quill. Its function is unknown. The colon is divided into three parts, the *ascending*, the *transverse* and the *descending;* the lower portion of the descending colon makes a double curvature called the *sigmoid flexure.* The rectum extends from the sigmoid flexure to the terminus of the intestinal canal, a distance of six or eight inches. (Fig. 68.)

217. The Liver is the largest glandular organ in the body, weighing about four pounds. It is situated in the right side below the diaphragm. It is convex above and slightly concave below. It has two principal lobes, the right lobe being four or five times larger than the left. On the under side of the liver is the gall-bladder, or reservoir for the bile, which opens by the common biliary duct into the duodenum.

218. The Pancreas* is a long, flattened organ, weighing three or four ounces, about six inches in length, and placed transversely across the posterior wall of the abdomen behind the stomach. A duct from this organ opens into the duodenum.

219. The Spleen (so called because the ancients supposed it to be the seat of melancholy) is an oblong, flattened organ, situated on the left side in contact with the diaphragm, stomach and pancreas. It is of a dark-bluish color, has no outlet, and its use is not well determined. (Fig. 68.)

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* Gr., *pan* all, and *kreas* flesh.

§ **19.** HISTOLOGY OF THE DIGESTIVE ORGANS.—*Lining Membrane of the Alimentary Canal—Of the Mouth. Histological Composition of the Tongue—Of the Palates—Of the Teeth—Pharynx. The Three Coats of the Œsophagus, the Stomach and the Intestines. Composition of the Liver—Spleen—Peritoneum.*

220. The alimentary canal is lined through its entire length by the *mucous membrane*, which, with its little recesses forming tubes or sacs called *glands*, is composed of three layers, the *epithelium* or surface layer, the *basement* membrane, and the *areolar-vascular* layer or corium. The epithelium varies in different parts, both in the number of layers and in the form of its cells.

Observation 1.—Diphtheria is a diseased condition of the epithelial tissue of the mouth and throat. Irritation of the epithelium of the stomach induces vomiting. A morbid state of the epithelial tissue of the small intestines causes diarrhœa. An inflammatory action of the epithelial part of the large intestine (the rectum) attends dysentery.

Observation 2.—In these diseases it is always safe to invite the blood to the skin by bathing, friction and extra coverings, to induce free and continued perspiration. *Large, warm* poultices, made stimulating by ground mustard or cayenne pepper, should be applied to the lower part of the face and throat for diphtheria, and to the stomach and abdomen for the other before-mentioned diseases. Abstinence from all stimulating food or drinks, also from medicinal "cure-alls," to "turn sickness" or "to check diarrhœa or dysentery," should be maintained. If rest and prolonged perspiration do not give relief, then send for a physician.

221. The cavity of the MOUTH, excepting the teeth, is everywhere covered with a highly vascular mucous membrane having a squamous epithelium, beneath which are concealed conical papillæ, excepting upon the gums and upper surface of the tongue, where they become conspicuous as organs of taste.

The TONGUE is a muscular organ, composed of two symmetrical halves, separated by a median fibrous membrane. Its muscles are named *extrinsic* and *intrinsic*. From the variety of the arrangement of the muscles, the tongue is capable of moving in all directions. (Fig. 66.)

The PALATE or roof of the mouth comprises two parts, the *hard* and the *soft* palate. The *Hard palate* is deeply vaulted

and lined with a smooth mucous membrane, excepting at the fore part, which is roughened by transverse ridges. The *Soft palate* is composed of a doubling of the mucous membrane, enclosing a muscular layer, together with several small glands.

222. The TEETH are appendages developed in the mucous membrane of the mouth. The hard substance is composed of *ivory* or *dentine*, *enamel* and *cement*. The *Dentine* forming the greater part of the tooth consists of microscopic tubes called *dental tubuli*. These tubuli are filled with minute processes of the pulp, affording nutrition, and perhaps giving sensibility to the dentine.

FIG. 69.

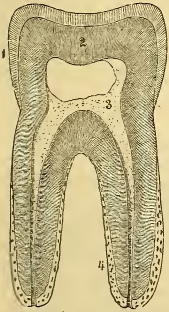

FIG. 69. VERTICAL SECTION OF A MOLAR TOOTH, moderately magnified.—1, Enamel, the lines of which indicate the arrangement of its columns. 2, Dentine, the lines indicating the course of its tubules. 3, Thin lamina of the dentine forming the wall of the pulp cavity, the dots indicating the orifices of the dental tubuli. 4, Cement.

The crown of the tooth is covered with *Enamel*, the hardest of all known animal textures, containing more earthy matter than the dentine, chiefly phosphate of lime. The *Cement* is a thin layer of true bone covering the fang, thinnest next to the enamel, and thickest along the grooves and near the point. (Fig. 69.)

223. The PHARYNX is a musculo-membranous bag, attached above to the base of the skull. Its walls consist chiefly of three pairs of constrictor muscles, supported by areolar tissue, and lined by mucous membrane which is continuous with that of the nasal cavities, Eustachian tubes, mouth, larynx and œsophagus, with all of which the pharynx communicates. The portion devoted to the passage of air has its epithelium *columnar* and *ciliated*, while that devoted exclusively to the passage of food and drinks has a *squamous non-ciliated* epithelium. Many mucous glands are found in the mucous membrane of the pharynx. (Figs. 66, 67.)

224. The walls of the ŒSOPHAGUS are composed of three coats—*muscular, areolar* and *mucous*. The *Muscular* coat has

an external layer of longitudinal fibres and an internal layer of circular fibres. The *Areolar* coat is soft and distensible. The *Mucous* membrane lies in folds, so that no opening exists when the œsophagus is not in action. Many mucous glands are found, especially at the ends.

225. The STOMACH is the dilated portion of the alimentary canal, into which the œsophagus opens from above by the cardiac orifice, and the small intestines from below by the pyloric orifice. It is a membranous bag, consisting of mucous

FIG. 70.

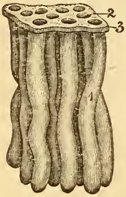

FIG. 71.

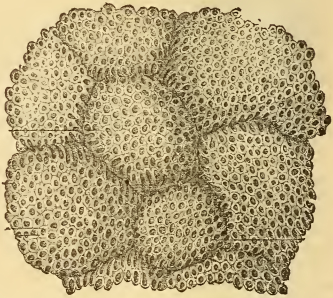

FIG. 70. SMALL PORTION OF THE MUCOUS MEMBRANE OF THE STOMACH, WITH THE IMBEDDED GASTRIC GLANDS.—1, The glands. 2, Orifices of the glands. 3, Epithelium of the mucous membrane. Moderately magnified.

FIG. 71. MAMMILLÆ OF THE MUCOUS MEMBRANE OF THE STOMACH, moderately magnified, exhibiting the orifices of the gastric glands.

membrane within, serous membrane without, with a muscular and areolar layer between. The muscular coat has three layers of fibres—*longitudinal, circular* and *oblique.*

The areolar coat is united to the muscular by loose areolar tissue, but the union is very firm between it and the mucous membrane which it supports. The mucous coat has numerous blood-vessels and lymphatics, also upright tubular glands, secreting the gastric juice. (Figs. 70, 71.)

226. The INTESTINES have their coats and muscular fibres arranged like those of the stomach. The areolar coat, with

its closely-adherent mucous membrane, projects into the interior of the small intestines, forming valves called *val'vulæ conniven'tes.* These vary in size, some being two inches long, and one-third of an inch wide in the middle, tapering at both ends; others are smaller, alternating with the layer. The intestinal mucous membrane is covered internally with thread-like processes of the membrane, which become erect when immersed in water, presenting a velvety appearance, hence called *villi.* (Figs. 71, 72.)

227. The LIVER has two coats—the external serous coat, formed from the doubling of the peritoneum upon it, and the internal areolar coat. Its proper substance is composed of a multitude of compressed polyhedral masses, not larger than a small pin's head, and named *hepatic lobules.*

FIG. 72.

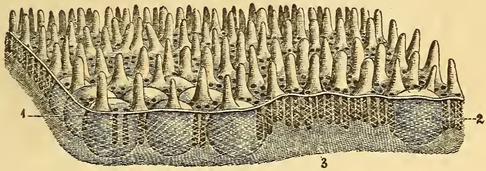

FIG. 72. PORTION OF THE MUCOUS MEMBRANE FROM THE ILEUM, moderately magnified, exhibiting the villi on its free surface, and between them the orifices of the tubular glands.—1, Portion of an agminated or clustered gland. 2, A solitary gland. 3, Fibrous tissue.

228. The SPLEEN has two coats—the outer, serous coat, being a reflection of the peritoneum; the inner, fibro-elastic coat is composed of white fibrous tissue mingled with elastic tissue; when torn, the lacerated surfaces present a deep reddish-brown, pulpy appearance, resembling coagulated blood.

229. The PERITONEUM is a serous membrane which invests all the abdominal viscera, and is then reflected upon the walls of the abdomen. The large doubling of the peritoneum reflected from the front of the vertebral column over the small intestine is called the *mesentery.*

FIG. 73.

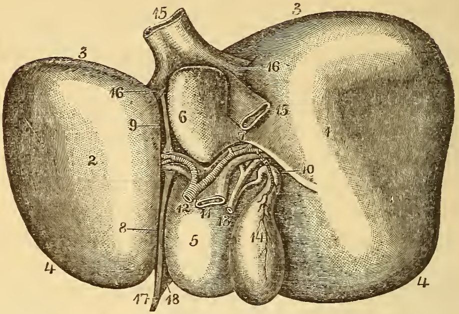

FIG. 73. INFERIOR SURFACE OF THE LIVER.—1, Right lobe. 2, Left lobe. 3, Posterior margin. 4, Anterior margin. 5, Quadrate lobe. 6, Caudate lobe. 7, Isthmus, or caudate process, connecting the latter with the right lobe. 8, 9, Longitudinal fissure. 10, Transverse fissure. 11, Portal vein. 12, Hepatic artery. 13, Common biliary duct, formed by the union of the hepatic and cystic ducts. 14, Gall-bladder. 15, Ascending cava. 16, Hepatic veins. 17, Round ligament. 18, Anterior part of the suspensory ligament.

§ **20.** CHEMISTRY OF THE DIGESTIVE ORGANS.—*Secretions effecting Chemical Changes during Digestion. Chemical Character of these Secretions—Of Mucus—Of Saliva—Of the Gastric Juice—Of Bile—Of the Pancreatic Juice—Of the Intestinal Juice. Relation of Acids and Alkalies in the Digestive Fluids.*

230. The chemical processes concerned in digestion consist of peculiar reactions between the food and the various secretions of the alimentary canal. These fluids are—*mucus* and *saliva,* secretions of the mucous membrane and glands of the mouth; *gastric juice,* a secretion of the stomach; *bile,* a secretion of the liver; *pancreatic juice,* a secretion of the pancreas; *mucus* and *intestinal juices,* secretions of the mucous membrane and glands of the intestines. Each of these fluids effects a special change in the constituents of food, till they are finally converted from an insoluble to a soluble condition, in which they may be absorbed.

231. MUCUS is a colorless and very viscid fluid found upon the mucous membrane, and secreted from the plasma of the

blood by the epithelial cells of that membrane. It is sometimes alkaline, sometimes acid, but perhaps, in its normal state, neutral.

232. SALIVA is a transparent, watery fluid. When first secreted, or during secretion, it is alkaline; in fasting, the moisture of the mouth is nearly neutral or even acid, but it consists at that time almost entirely of mucus. The chemical action of saliva is—*first,* that of a solvent; it dissolves saline substances, organic acids, alcohols and ethers, gum, sugar and the soluble albuminoid and gelatinoid bodies. *Second,* the saliva converts starch granules into dextrine, then into soluble dextrose, glucose or grape-sugar. A mixture of all the fluids of the mouth appears to form the most active combination for this purpose.

233. The GASTRIC JUICE is a colorless or pale-yellow, transparent, slightly viscid and strongly acid fluid. *Pepsin* is its characteristic constituent. Though the most powerful solvent known, the gastric juice seems to have no effect upon *living* animal substances; hence the membranes of the stomach remain intact as long as their vital power continues. Gastric juice changes cane-sugar into glucose—albuminous substances, as albumen, fibrin, casein, etc., into substances called *peptones.* Gelatinous substances are changed chemically by the gastric juice, and lose their property of gelatinizing when cold.

234. BILE is a somewhat viscid, glutinous and bitter fluid, of a dark golden-brown color. It is but slightly alkaline, and is sometimes neutral. In digestion it is an important agent, but its action does not depend upon an albuminoid, like saliva. Bile dissolves neither albuminoid substances nor fat, but probably emulsifies the latter.

235. The PANCREATIC JUICE is somewhat viscid, transparent, colorless and inodorous. It is more strongly alkaline than saliva; as digestion goes on, it becomes more alkaline and less viscid. Its most peculiar constituent is *pancreatin,* an albuminoid substance whose special composition is not yet determined. Its chief office seems to be to emulsify fatty matters, in which it probably acts with the bile.

236. The composition of INTESTINAL JUICES is not well known. They probably differ from common mucus, and have special properties. They are colorless, viscid, and contain from two to five per cent. of solid matter. They appear to be alkaline in the ileum, or lower part of the small intestines, acid in the cœcum, or beginning of the large intestines, and alkaline through the remainder.

237. The changes which take place in the three *staminal principles* of food—*saccharine*, *albuminoid* and *oleaginous* substances—from their entrance into the mouth till ready for absorption, sum up as follows: The conversion of starch commences with the saliva; that of albuminoids and cane-sugar with the gastric juice; the emulsifying of fats with the bile and pancreatic juice. These processes go on independently of each other, the salivary action being unaffected by the gastric, but both functions are somewhat aided by the pancreatic juice, the intestinal juice coming in as a general auxiliary agent, to complete and harmonize the several operations commenced at different points in the alimentary canal.

238. It will be noticed in the digestive fluids that there are successive alternations of alkali and acid, the saliva being alkaline; the gastric juice, acid; the pancreatic juice, bile and juice of the ileum or third part of the small intestine, more or less alkaline; that of the cœcum of the large intestine, acid; that of the remaining portion, alkaline—alternations giving neutralizations of great importance in the chemistry of digestion.

§ **21.** PHYSIOLOGY OF THE DIGESTIVE ORGANS.—*The Assimilation of Food. Process by which Food is transformed into Chyle. Destination of the Chyle.*

239. Food is necessary to the preservation and growth of the body, but it must first be *animalized* or *assimilated;* that is, converted into matter having the *same characteristics* as those animal substances into which it is at length to be incorporated. We may include under the term *Primary As-*

similation those animalizing changes necessary to the conversion of food into *chyle* and *blood;* under *Secondary Assimilation,* those necessary to the conversion of blood into integral parts of *solid tissue.* The *first* series of changes is included in the process, named *Digestion,* by which food is transformed from its crude state into *Chyle.*

240. The alimentary canal in which these digestive changes take place is like a long manufacturing establishment with many apartments, the first room being the mouth or masticating room, where some of the workmen cut the food; some grind it; some moisten it and supply the needed chemicals for making one of the animalizing changes. Mastication being completed, at the word of command the obedient muscles, with the greatest promptness and efficiency, convey the food onward to that wonderful laboratory, the stomach. The muscles of the soft palate raise the curtain from the base of the tongue and incline it backward, closing the opening into the nostrils; those of the small open lid of the trachea, the epiglottis, close the lid tightly that the food may pass safely over, while the muscles of the tongue, cheeks and floor of the mouth force the food back into the pharynx and the œsophagus, the circular muscles of which, by alternate relaxation and contraction, urge it into the stomach. Here the food is subjected to a remarkable chemical agent, the Gastric Juice, which changes it from a crude state into a soft, homogeneous pulp called *Chyme.* (Figs. 66, 67, 68, 73.)

241. Recent investigations show that this juice is less of a "universal solvent" than was formerly supposed—that its chemical power is limited to azotized substances, changing albuminoids into albuminose and gelatinoids into gelatinose, the conditions best adapted to assimilation. The change in starch, which continues in the stomach, is effected by the presence of the saliva, which commenced its work in the mouth. Fatty matters are only reduced to a fine state of division and held in suspension by the pulpy chyme.

During these processes the mass is undergoing a churning or rotary motion by the joint manipulations of the longitudi-

nal, circular and oblique muscles, thus bringing part after part into the immediate presence of the Gastric Juice. While digestion is thus going on the openings of the stomach are well guarded. A return of any part of the mass into the œsophagus is prevented by the sphincter muscles near the cardiac orifice, and the passage to the intestine is closed by the sphincter muscles of the pyloric orifice and a valve called the pylorus or "gate-keeper," which, true to its name, stands a faithful sentinel till proper chyme presents itself, showing evidence of having completed the prescribed curriculum. This sentinel-commission seems to last only during the process of digestion, as afterward many substances previously detained are allowed free egress. (Fig. 68.)

242. After passing the pyloric orifice the chyme is treated by other chemical agents, the bile, the pancreatic and intestinal juices continuing the chemical process commenced in other parts of the alimentary canal. The fats are reduced to an exceedingly fine state of emulsion. The whole pulp is subjected to the constant wave-like or peristaltic muscular action of the intestines which forces their contents to their respective destinations. The nutritive portion or chyle is taken up by the absorbent vessels and conveyed to the blood, while the innutritious portion is excreted from the system.

243. The absorbing surface of the intestines is enormously increased by the projecting forms and great abundance of the *villi;* they hang out into the nutritious, semi-fluid mass contained in the cavity of the intestines as the roots of a tree penetrate the soil, imbibing the liquid portions of food with wonderful rapidity. (Figs. 17, 72.)

§ **22.** Hygiene of the Digestive Organs.—*Suggestions relative to the Preservation of the Teeth—To their Removal. Conditions affecting the Quantity of Food demanded by the System—The Quality of Food. Directions relating to the Manner of taking Food. Conditions of the System requisite for the proper Digestion of Food.*

244. *For the Preservation of the Teeth* the first requisite is to keep them clean. After meals they should be cleansed to prevent the collection of *tártar* and to remove any remaining

particles of food. Night and morning the mouth should be cleansed with pure tepid water, after which the teeth should be thoroughly brushed on both surfaces. Occasionally, refined soap may be used if followed by thorough rinsing of the mouth. Tobacco contains a "grit" which injures the enamel. It also discolors the teeth, debilitates the vessels of the gums, taints the breath and renders the appearance of the mouth forbidding.

245. *The Removal of the Teeth.* The temporary teeth should be removed at once when loose, and often before, when the permanent teeth appear. This is essential to the regularity and beauty of the second set.

Irregular or crowded permanent teeth generally require the removal of one or more. By pressure upon each other the enamel is injured and the appearance rendered unsightly.

Observation.—Toothache does not always indicate the necessity of extraction, as the nerve or investing membrane may be diseased and the tooth sound. When the removal of a tooth is necessary, apply to some skillful operator; something more is needed than strong muscles and a pair of forceps. Skill is as requisite in the proper extraction of a tooth as in the amputation of a limb.

246. The health of the Digestive Organs in general requires the observance of certain conditions relative to their natural stimulus, *Food.* These will be considered under the following heads: 1. *The Quantity of Food.* 2. *The Quality of Food.* 3. *The Manner of taking Food.* 4. *The Proper Conditions of the System for receiving Food.*

247. The QUANTITY OF FOOD necessary to the system varies, being affected by age, occupation, temperament, habits, temperature, amount of clothing, health and mental state.

248. *The supply must equal the waste of the system.* In every department of nature waste attends action. The greater the amount of exercise, the more rapidly will the particles be worn out and removed and their places need supplying with new atoms.

During the period of growth the supply must exceed the waste, for the building of new tissues. This accounts for the keen

appetite and vigorous digestion in childhood. The same is true when persons have become emaciated from famine or disease.

249. *When exercise is lessened, the quantity of food should be proportionally diminished,* otherwise the tone of the digestive organs will be impaired and the health of the system enfeebled. This is especially applicable to students who have been accustomed to laborious employments.

250. *More food is required in winter than in summer;* hence, by diminishing the amount of food as the warm season approaches, the tone of the stomach and vigor of the system will be better maintained, thus lessening the liability to "summer complaint."

251. *The amount of food should be adapted to the present condition of the digestive organs.* Imperfectly digested food irritates the mucous membrane of the intestines and debilitates the system instead of invigorating it. In sickness, the attending physician is the person to decide respecting the proper amount, as diseased tissues suffer from undue action. In health, the natural appetite is generally a safe guide as to plain, nutritious food; but condiments, spices, etc., excite a morbid appetite, whose cravings it is unsafe to gratify.

252. The QUALITY OF FOOD *should be both nutritive and digestible.* Substances are *nutritious* in proportion to their capacity to yield the constituents of chyle. Substances are *digestible* in proportion to the facility with which they are acted upon by the digestive fluids. Articles highly nutritive in themselves, but difficult of digestion, often yield less nourishment than those poorer in nutritive quality but easy of digestion. If we confine our diet to easily digested articles, the digestive organs will be weakened from want of proper exercise; if too highly concentrated diet, they will be injured by over-work; hence the necessity of choosing, in this respect, the "happy medium." Variety in food is as essential in the domestic animals as in man.

253. *Proper aliment must contain the three staminal principles of food.* These are albuminous, oleaginous and saccha-

rine substances; the first contain carbon, oxygen, hydrogen and nitrogen; the last two are destitute of nitrogen. Various experiments have shown that if we feed upon any one of these groups to the exclusion of the other two, or upon any two to the exclusion of the third, the health will be impaired. Milk contains all the food principles, the albuminous being furnished by its casein; the oily, by the butter; and the saccharine, by the sugar of milk. Beef is rich in fat and albumen, and also contains *inosit* or muscle-sugar. Most of the cereals contain gluten (an albuminoid), starch, sugar and oil. Wheat, however, has the first three constituents without the oil. It is most nutritious in the form of "Graham flour;" by rejecting the *bran*, most of the gluten is lost. Eggs are very rich in albumen, and the yolk also contains oil. Beans, peas, etc., afford starch and much legumine (an albuminoid). Potatoes abound in starch. Sago, tapioca, rice, arrow-root, etc., are constituted almost wholly of starch. These articles or their substitutes, properly combined, will yield the necessary elements to the system.

254. *Food should be properly cooked.* However nutritious an article of food may be, if not well cooked it is not only unsavory to the palate, but hurtful to the digestive organs. The simplest methods of preparation by cooking are the best. Meat should be broiled, roasted or made into soup.

The cooking of *vegetables* should be thorough and complete. The proper *combination* and *cooking* of a few articles of food (as flour, milk, eggs and butter) require skill, which in reality assumes the importance of no inferior art.

255. *The Quality of Food should be adapted to the season and climate.* Highly stimulating food may be used almost with impunity during the cold season of a cold climate, but in the warm season and in a warm climate it is very injurious. Animal food, being more stimulating than vegetable, is therefore well adapted to winter, and vegetable to spring and summer. Where the digestive organs are weakened or diseased, it is very important that a nutritious vegetable diet be adopted as the warm season approaches.

256. *Vegetable diet is most suitable for children.* The organs of a child are more sensitive and excitable than those of an adult; hence, stimulants of every kind should be strictly avoided, and the food mainly of a vegetable character. In this "fast age," this is a suggestion of vast importance. Parents mourn over many evil effects of unrestrained passion and moral deterioration in the rising generation, while in truth these are too often but the legitimate harvest of the seed they have themselves sown in the form of stimulating food and drinks. The old spelling-book assertion that "bread and milk is the best food for children" is as true now as it was in the days of our fathers.

257. THE MANNER OF TAKING FOOD exercises a controlling influence upon the health of the digestive organs. It is essential that the *food be properly masticated*, to secure the fine division necessary to the proper action of the gastric juice and other fluids, and especially to mix the food with the requisite amount of saliva. Rapid eating should be avoided, not only as a violation of good table manners, but as a violation of the laws of our physical nature, whose penalty, in the form of dyspepsia with its numerous train of evils, will sooner or later be visited upon the transgressor.

258. *Drink should not be taken with the food.* Nature supplies the appropriate moisture, and if tea, coffee or any other fluid be used as a substitute, indigestion will follow from the absence of the necessary amount of saliva. Again, drinks taken into the stomach must be absorbed before the digestion of other articles is commenced. Thirst between the meals does not always arise from a demand of the system for fluids, but may be induced by fever or local disease of the parts connected with the throat. This may often be relieved by chewing a cracker or some other dry substance, thus exciting the salivary glands. This is a safe resort when thirst accompanies a heated condition of the system arising from over-exercise, while the practice of taking cold fluids is dangerous and should never be indulged.

259. *Regard should be paid to the temperature of food and*

drink. Hot food or drink for a short time unduly stimulates the vessels of the mucous membrane of the gums, mouth and stomach; then reaction follows, bringing loss of tone and debility of these parts. This practice is a fruitful cause of spongy gums, decayed teeth, sore mouth and indigestion. On the other hand, if food or drink be taken too cold, an undue amount of heat is abstracted from the stomach; this arrests the digestive process, and thus deranges the system.

260. *Food should be taken at regular and suitable periods.* The interval between the meals should be regulated by the character of the food, and the age, health, exercise and habits of the individual. In the young, the active and the vigorous, food is more rapidly digested than in the aged, the indolent and the feeble; consequently, it should be taken more frequently by the former class than by the latter.

261. THE CONDITIONS OF THE SYSTEM FOR RECEIVING FOOD are important in digestion.

Food should not be taken immediately before or after severe exercise of body or mind. The functional exercise of any organ abstracts fluids, sanguineous and nervous, from other parts of the body, thus weakening those parts for the time. Severe exercise of the muscle concentrates the forces in the muscle; severe exercise of the brain concentrates the forces of the brain; the same is true of the vocal and other organs. After severe exercise, from thirty to forty minutes should be allowed before eating, for restoring equilibrium to the system. The student, farmer or mechanic who hurries from his toil to his dinner to "save time" will, in the end, lose more time than he saves. After eating, the digestive organs need, for a time, the chief use of the vital forces, and if they are habitually expended elsewhere, as in study or labor, digestion will be arrested, the chyle cheated of its proper elements, and headache, dullness and general derangement will follow.

Observation.—When horses and oxen have been worked hard, water or food should not be given as soon as they are stabled. The noon meal of the worked domestic animal should be light. Neither *water* nor food should be given the hard-driven horse until he is rested.

262. *Persons should abstain from eating at least three hours before retiring for sleep.* It is no unusual occurrence for those persons who have eaten heartily immediately before retiring to have unpleasant dreams, or to be aroused from their unquiet slumber by colic pains. In such instances, the brain becomes partially dormant, not imparting to the digestive organs the requisite amount of nervous influence; this being deficient, the unchanged food remains in the stomach, causing irritation of this organ.

Observation.—A healthy farmer who was in the habit of eating a quarter of a mince pie just before retiring became annoyed with unpleasant dreams, and among the images of his fancy he saw that of his deceased father. Becoming alarmed, he consulted a physician, who, after a calm hearing, advised the patient to eat *half* a mince pie, assuring him that then he would *see his grandfather.*

263. *The mental state exerts an influence upon the digestive process.* This is clearly exhibited when an individual receives sad intelligence. Let him be sitting at a plentiful board with a keen appetite, and the unexpected news destroys it, because the excited brain withholds the stimulus; hence all unpleasant themes, labored discussions or matters of business should be banished from the table. Light conversation, enlivening wit and cheerful humor wonderfully promote digestion.

Indigestion arising from nervous prostration should be treated with great care. The food should be simple, nutritious, properly cooked, moderate in quantity and taken at regular periods. Large quantities of stimulating food, frequently taken, serve to increase the nervous prostration. Exercise in the open air and a cheerful state of mind are very beneficial in restoring the natural, healthy action of the brain, and thus aiding the digestive powers.

264. *After long abstinence unstimulating food should be taken, and in small quantities.* As in case of sickness, when the appetite begins to return, the nurse must use much discretion, and the patient, often, self-denial. The popular adage that "food never does harm when there is a desire for

it" is untrue. Too frequently, when a patient satisfies his cravings, it is to induce relapse into the former disease, and at the risk of life. The digestive organs are weak, and must be gradually brought into action. It is often better to give the food in a solid rather than liquid form, so that the salivary and mucous glands may be stimulated to action.

265. *The condition of the skin exercises an important influence upon digestion.* Let free perspiration be checked, either from uncleanliness, chills or any other cause, and the functional action of the stomach is diminished. This is one of the fruitful causes of "liver and stomach complaints" among the filthy and half-clad inhabitants of our cities and villages. Attention to bathing and clothing would prevent many "season complaints," especially among children.

Observation.—The useful cow should be protected from chilling rains and frosts. It is poor economy to have the skin of any domestic animal chilled.

266. *Pure air is necessary to give a keen appetite and vigorous digestion.* The digestive organs must have a plentiful supply of pure blood, and to have pure blood we should breathe pure air. Poor ventilation is a frequent cause of indigestion. Persons who sleep in ill-ventilated rooms have little or no appetite in the morning. A manufacturer stated before a committee of the British Parliament that he had removed an arrangement for ventilating his mill, as he noticed that his men ate much more after his mill was ventilated than before, and he could not *afford* to have them breathe the pure air. Compression of the vital organs prevents the introduction of a sufficient supply of pure air, and is one of the causes of dyspepsia, now so prevalent among ladies.

General Observations.—All aliment is separated into nutriment and residuum. The latter should be regularly expelled from the system, otherwise headache, dizziness and general uneasiness will ensue, and if allowed to continue, the foundation will be laid for a long period of suffering and disease. For the preservation of health, there should be in most persons a daily evacuation of residual matter. Evening is the best time; especially is this true when persons are afflicted with piles.

Constipation may, in many cases, be relieved by friction over the abdominal organs, and by making an effort to evacuate the residuum at some stated period each day.

Recapitulation.—Digestion is most perfect when the action of the cutaneous vessels is energetic; the brain moderately stimulated; the blood well purified; the muscular system duly exercised; the food properly cooked and masticated, taken at regular periods, and adapted in quality and quantity to the present condition of the individual.

§ **23.** Comparative Splanchnology.—*Nutritive Apparatus of Vertebrates. Compare the Mouths and Teeth of Vertebrates—The Stomach and Intestines of Vertebrates—Nutritive Apparatus of Mollusca and Annulosa—Of Radiata—Of Protozoa.*

267. In the Nutritive Apparatus of all vertebrates, as in the Motory, a general plan of parts obtains, subject to the variations required to preserve the harmony of relation between the organization and the *use* to which it is to be applied.

Fig. 74. Fig. 75.

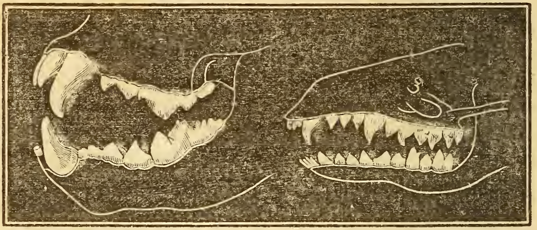

Fig. 74 represents the Teeth of Carniv ra or Flesh-eating Animals.
Fig. 75 represents the Teeth of Insectivora or Insect-eating Animals.

268. In no part do we find a greater variety or a nicer accommodation to particular wants than in the Mouths and Teeth of different animals. In *Mammals* the projecting jaws, the wide mouth, the strong, pointed, sharp, enameled edges of the teeth enable carnivorous or flesh-eating animals to seize and hold their prey, and the hinge-like movement of the jaw to divide it like a pair of scissors, as seen in the Cat and the Lion. (Fig. 74.) The full lips, the rough tongue, the furrowed, cartilaginous palate, the broad, rough surface

of the teeth, the central plates of enamel and the lateral movement of the jaw qualify the herbivorous or grain-eating animals for grazing and for grinding their food, as grain is crushed between the upper and nether millstone, as in the Sheep and Horse. The elongated, tapering muzzle, the cone-pointed, enameled molars locking into the enameled depressions of the opposite jaw, enable the insectivorous animals to burrow in the earth for the insects and worms upon which they feed, and also to crush them, as in the Mole and Hedgehog. (Fig. 75.) The two chisel-shaped incisors, enameled only in front, allowing more rapid wear of the posterior than the anterior part, keeping them always sharp; the bag of pulp at the base of these teeth, providing for growth equal to

FIG. 76.

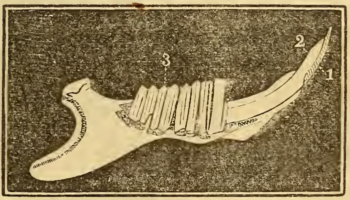

FIG. 76. LOWER JAW OF A SQUIRREL.—1, The enamel of the gnawing tooth. 2, The ivory. 3, The lateral furrows of the molar teeth.

the wear at the top; the backward and forward movement of the jaws and the great size and strength of the lower jaw, adapt the rodentia or gnawers to their mode of life, as in the Rat and the Squirrel. (Fig. 76.)

269. In *Birds* the mouth receives a new character both in substance and in form. Instead of fleshy lips and teeth of enameled bone we have the hard and horny investment of the jaws, known as the *bill*, destitute of true teeth. This organ varies in size and form according to the food of the species, which may be grains, insects, fishes or flesh.

270. In all carnivorous *Reptiles* the prey is swallowed whole; hence their jaws and throats are made capable of great dila-

tation. Their teeth are used only for seizing and retaining their prey, but not in any way for dividing it.

271. Some species of *Amphibians,* as Frogs, have only the upper jaw armed with teeth. The structure of the tongue of the Toad is like that of the Frog (attached to the floor of the mouth), but the jaws are not furnished with teeth.

272. The teeth of *Fishes* vary much in form in different species, being sometimes fine and thickly set; in others they are strong hooks or sharp-cutting plates.

273. The Stomach and Intestines of vertebrates vary in size, form and relative length. They are simpler, harder

Fig. 77.

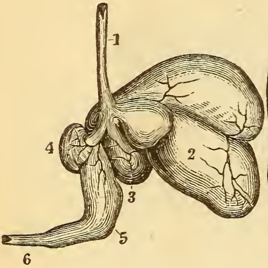

Fig. 78.

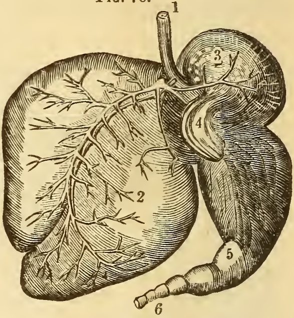

Fig. 77. Stomach of the Sheep.—1, The œsophagus. 2, The rumen. 3, The reticulum. 4, The omasum. 5, The abomasum or rennet. 6, The intestine.

Fig. 78. Stomach of an Ox.—1, The œsophagus. 2, The rumen (paunch). 3, The reticulum (honeycomb). 4, The omasum (many-plies). 5, The abomasum (rennet). 6, The intestine.

and shorter in carnivorous than in herbivorous or granivorous animals; while the Ox has intestines about twenty times the length of his body, those of the Lion are but three or four times its own length.

274. Ruminants, as the Sheep and Ox, have a stomach with four cavities. The first stomach, called the *Ru'men* or "*Paunch;*" the second, the *Retic'ulum* or "*Honeycomb;*" the third, the *Oma'sum* or "*Many-Plies;*" the fourth, the *Ab'oma-*

sum or "*Rennet;*" the latter, taken from the young calf, is used in cheese-making. (Figs. 77, 78.)

FIG. 79.

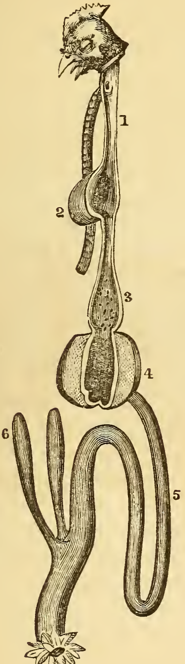

FIG. 80.

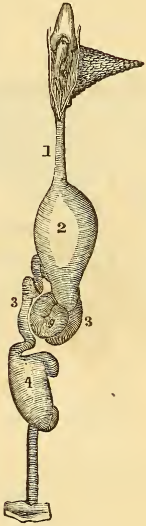

FIG. 79. THE ALIMENTARY CANAL OF A FOWL.—1, The œsophagus. 2, Ingluvies (crop). 3, Proventiculus (secreting stomach). 4, Triturating stomach (gizzard). 5, Intestine. 6, Two cæca.

FIG. 80. THE ALIMENTARY CANAL OF THE FLYING LIZARD.—1, The œsophagus. 2, The stomach. 3, 3, Small intestine. 4, Large intestine.

The food when first swallowed is received into the Rumen, where it accumulates while the animal is feeding. Here it is

moistened by the fluids secreted by the walls of this cavity. It then passes into the Reticulum, where it receives additional secretions, and is made into little pellets or "cuds," which, when the animal is at rest, are returned to the mouth to be re-chewed and mixed with the saliva. This pulp passes directly into the third cavity to be prepared for the fourth, where digestion is finally completed. It is then received by the intestinal canal.

FIG. 81.

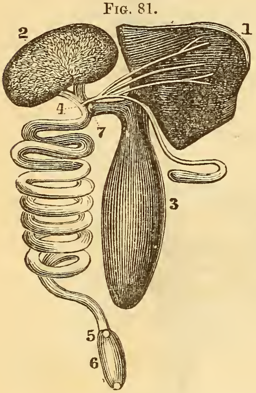

FIG. 81. THE ALIMENTARY CANAL OF THE SWORD-FISH.—1, Liver. 2, 3, Cæcus or pouches connecting with small intestine. 4, 5, Small intestine, coiled. 6, Large intestine. 7, Biliary duct.

275. In *Birds* there are usually three cavities or stomachs; the first is a dilatation of the œsophagus, called the *Crop* or "*Inglu'vies,*" where the food is macerated and softened; the second is the true stomach, named "*Proventic'ulus,*" where the mucous membrane is provided with mucous follicles, secreting an acid which acts still farther upon the food; and the third is the *Gizzard* or *Trit'urating* cavity. The latter, in granivorous birds, has immense strength, being composed of muscular fibres running in different directions and lined with a horny membrane. Gravel and angular stones are instinctively swallowed to assist in the grinding process. In flesh-eating birds the gizzard is thin and membranous. The commencement of the large intestine is furnished in most birds with two blind tubes or cæca; their exact function is still questionable. (Fig. 79.)

276. In *Reptiles* the alimentary canal differs much from that of mammals or birds. As a general rule, it is shorter in proportion to the trunk than in warm-blooded vertebrates. The transition from the œsophagus to the stomach is by a

pouch-like enlargement; although the prey of many reptiles passes into the stomach whole, nothing is permitted to pass out into the intestines but chyme and other fluids. The small intestines usually have a few coils; the large intestines in most reptiles are short, simple and straight. The stomach of the Frog is pear-shaped, placed in the left side of the abdomen. (Fig. 80.)

277. In *Fishes*, the alimentary canal is more diversified in length, size and form than in reptiles. There are two predominant forms of the stomach in fishes—one like a bent tube (siphonal), and the other a blind tube (cæcal) (Figs. 81, 82). In some species of fish, the small intestines extend in a line from the stomach to their termination; in others there

FIG. 82.

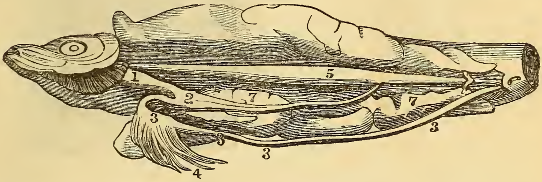

FIG. 82. THE ALIMENTARY CANAL OF THE HERRING.—1, Œsophagus. 2, Stomach. 3, 3, 3, 3, Small intestine. 4, Cæca. 5, Air-bladder. 7, Pneumatic duct.

are found from two to eight coils. The large intestines are short and straight, and the termination of the rectum opens into a cavity called the *Cloaca*. The liver is usually large, with numerous appendages. In the cod it is soft and saturated with oil, which is expressed for medicinal purposes.

278. The object of digestion in Invertebrates as well as Vertebrates is to separate the nutrient part of the aliment from the non-nutrient portion or residuum, so that the former may be converted into liquids adapted to mingle with the blood.

279. The ANNULOSA and MOLLUSCA are furnished with a distinct alimentary canal that does not open into the body-cavity. In most cases the digestive canal communicates with

the outer world by two openings—a mouth and an excretory aperture.

280. In the RADIATA, the digestive cavity is a pouch with a single opening, into which the food is passed and from which the residuum is ejected, as in the Hydra. (1–Fig. 84.)

FIG. 84.

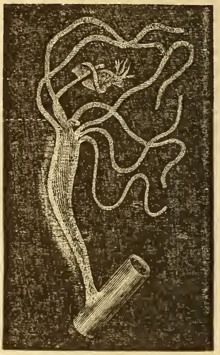

FIG. 83.

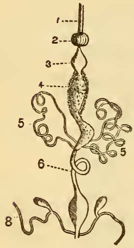

FIG. 83. DIGESTIVE APPARATUS OF A BEETLE.—1, Gullet. 2, Crop. 3, Gizzard. 4, Chylific stomach. 5, Malphigian tubes or cæca. 6, Intestines, with cloaca. 8, Renal vessel.

FIG. 84 REPRESENTS THE DIGESTIVE APPARATUS of the Hydra or Fresh-water Polyp.

281. In the PROTOZOA there is no digestive apparatus, or only a rudimentary one. The process of nutrition is carried on in the simplest possible manner, and with the simplest possible apparatus. The only distinct structure which is at all concerned in nutrition is a contractile cavity which opens and closes at definite intervals.

ANALYTIC EXAMINATION.

206. In what processes are the organs of the Nutritive Apparatus used? Name the organs.

Chapter VI.—The Digestive Organs.

§ **18.** *Anatomy of the Digestive Organs.*—207. What are included in the Digestive Organs? 208. Describe the Mouth. 209. What is said of the Teeth? Give the parts of each tooth. 210. What are the temporary teeth? The permanent? Name and describe the different forms of the teeth. 211. Define a Gland. Of how many pairs do the Salivary Glands consist? Name and describe each pair. Observation. 212. Describe the Pharynx. 213. What is the Œsophagus? 214. What is said of the Stomach? 215. Mention the divisions of the Intestines. Describe the small intestine. 216. State the length and parts of the large intestine. Describe each part. 217. Describe the Liver. How many lobes? What is on the under side? 218. What is said of the Pancreas? 219. What is the Spleen?

§ **19.** *Histology of the Digestive Organs.*—220. By what is the alimentary canal lined? Observations. 221. Describe the lining membrane of the mouth. Describe the tongue. Name its muscles. Distinguish between hard and soft palate. 222. What is the relation of the teeth to the mucous membrane of the mouth? Give the composition of the hard substance. Describe each part. 223. Describe the walls of the Pharynx. 224. Name and describe the coats of the Œsophagus. 225. Describe the Stomach and its coats. 226. What is said of the coats and muscular fibres of the intestines? What are the Valvulæ Conniventes? Describe the Villi. 227. How many coats has the Liver? 228. Describe the coats of the Spleen. 229. What is the Peritoneum?

§ **20.** *Chemistry of the Digestive Organs.*—230. What secretions effect chemical changes during digestion? 231. What is Mucus? 232. Describe Saliva. What is said of it when first secreted? State its chemical effect. 233. What are the properties of Gastric Juice? Name its characteristic constituent. What of its solvent power? What changes does it effect? 234. Describe Bile. What changes caused by it? 235. What is said of the Pancreatic Juice? Its office? 236. Speak of the Intestinal Juices. 237. State the summing up of the changes in three staminal principles of food. 238. What is the relation of acid and alkali in the digestive fluids?

§ **21.** *Physiology of the Digestive Organs.*—239. What change in food is necessary? What is Primary Assimilation? What Secondary? What is Digestion? 240. To what is the alimentary canal likened? 241. What do recent investigations show respecting the Gastric Juice? Speak of the changes of food in the stomach. Can the food return to the œsophagus? Why not? When does the food leave the stomach? What is there peculiar about the Pylorus? 242. What changes occur in the alimentary canal? 243. How is the absorbing surface of the intestines increased? What becomes of the nutritive portion of the food?

§ **22.** *Hygiene of the Digestive Organs.*—244. Name the first requisite for the preservation of the Teeth. What objection to the use of tobacco? 245. When should the temporary teeth be removed? What do the irregular permanent teeth generally require? Observation. 246. What is required for the health of the Digestive Organs? 247. What is said of the quantity of food? 248. What must the supply equal? When must supply exceed waste? 249. When should the quantity of food be diminished? 250. Is more or less food required in winter than in summer? 251. To what should the amount be adapted? 252. What should be the quality of food? Distinguish between nutritious and digestible substances. 253. What must proper aliment contain? 254. How should food be cooked? What are the best methods of preparation? 255. To what should the quality be adapted? 256. What is said of vegetable diet? 257. What is said of the manner of taking food? Why should food be properly masticated? 258. Why not take drink with food? What

is said of thirst between meals? 259. Why should regard be had to the temperature of food and drink? 260. How and when should food be taken? 261. State the reason for not taking food just before or after exercise. Observation. .262. Why is it not best to eat immediately before retiring to sleep? Observation. 263. What influence does the state of the mind exert upon the digestive organs? How should indigestion arising from nervous prostration be treated? 264. After long abstinence, what kind of food should be taken? 265. What influence does the condition of the skin exert? Observation. 266. Why is pure air necessary? General Observation. Recapitulation.

§ **23.** *Comparative Splanchnology.*—267. What is said of the Nutritive Apparatus of Vertebrates? 268. Compare the mouth and teeth of the Vertebrates. 269. Of Birds. 270. Of Reptiles. 271. Of Amphibians. 272. Of Fishes. 273. Speak of the stomach and intestines of Vertebrates. 274. Describe the stomach and give the process of digestion in Ruminants. 275. Name and describe the stomachs of Birds. 276. Speak of the digestive organs of Reptiles. 277. What is said of the stomach and alimentary canal in Fishes? 278. What is the object of digestion in Invertebrates? 279. Speak of the digestive organs in the Annulosa and Mollusca. 280. In the Radiata. 281. In the Protozoa.

UNIFIC REVIEW.

[Compare 208–210 with 222 and 267–272.]

Compare the mouth and teeth of man with those of the lower animals.

[Compare 214–216 with 223–226 and 273–281.]

Contrast the alimentary canal of man with that of the different sub-kingdoms and classes.

[Compare 217 and 227 with 277.]

What is said of the liver in different animals?

[Compare 220–226 with 30–37 and 478–480.]

Describe the lining membrane of the mouth and alimentary canal.

[Compare 230–238 with 38–44, 50–53, 58 and 60–63.]

Give an outline of the Chemistry of the Digestive Organs.

[Compare 239–243 with 274 and 275.]

Compare the digestive processes in different classes of animals.

[Compare 261–266 with 192, 195, 373–377 and 438–446.]

In what condition should the system be to take food without injury? State the influence of exercise upon digestion. What does the health of the human system require?

Fig. 85.

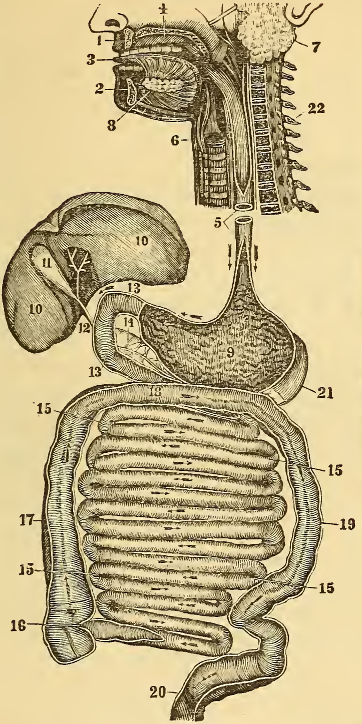

Fig. 86.

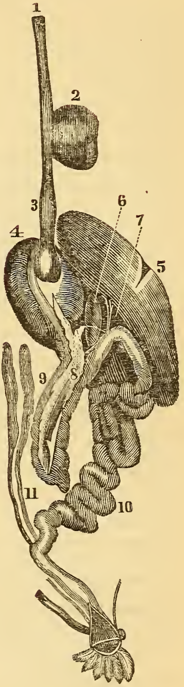

Fig. 85. An Ideal View of the Organs of Digestion, opened nearly the whole Length.—1, The upper jaw. 2, The lower jaw. 3, The tongue. 4, The roof of the mouth. 5, The œsophagus. 6, The trachea. 7, The parotid gland. 8, The sublingual gland. 9, The stomach. 10, 10, The liver. 11, The gall-cyst. 12, The duct that conveys the bile to the duodenum (13, 13). 14, The pancreas. 15, 15, 15, 15, The small intestine. 16, The opening of the small intestine into the large intestine. 17, 18, 19, 20, The large intestine. 21, The spleen. 22, The upper part of the spinal column.

Fig. 86. Digestive Apparatus of a Fowl.—1, The œsophagus. 2, The crop. 3, The second stomach. 4, The gizzard. 5, The liver. 6, The gall bladder. 7, The bile ducts. 8, The pancreas. 9, The duodenum. 10, The large intestine. 11, The two cæca.

SYNTHETIC TOPICAL REVIEW.

Mouth,	§ 18. *Anatomy of.*	CHAP. VI. *Digestive Organs.*
Teeth,		
Salivary Glands,		
Pharynx,		
Œsophagus,		
Stomach,		
Intestines,		
Liver,		
Pancreas,		
Spleen.		
Alimentary Canal, Lining membrane of	§ 19. *Histology of.*	
Mouth, " "		
Tongue, " "		
Palates, " "		
Teeth, " "		
Pharynx, " "		
Œsophagus, Coats of		
Stomach, "		
Intestines, "		
Liver, "		
Spleen, "		
Peritoneum.		
Secretions, Names of	§ 20. *Chemistry of.*	
" Character of		
Mucus,		
Saliva,		
Gastric Juice,		
Bile,		
Pancreatic Juice,		
Intestinal Juices,		
Changes in Food,		
Acids and Alkalies.		
Assimilation,	§ 21. *Physiology of.*	
Chymification,		
Chylification,		
Destination of Chyle.		
Teeth, Preservation of	§ 22. *Hygiene of.*	
" Removal of		
Food, Quantity of		
" Quality of		
" Manner of taking		
Condition of the System.		
Vertebrates, Nutritive Apparatus of	§ 23. *Comparative Splanchnology.*	
" Mouth and Teeth,		
" Stomach and Intestines,		
Invertebrates, Digestion in		
Mollusca and Annulosa, Digestion in		
Radiata, "		
Protozoa. "		

State the Anatomy, the Histology, the Chemistry, the Physiology and the Hygiene, Human and Comparative, of the Digestive Organs.

CHAPTER VII.

ABSORPTION.

282. We have observed the changes in food till its formation into chyle—changes which have taken place in the alimentary canal, and which are included under the general term *Digestion.* The chyle, however, is virtually *external* to the animal body. The process by which it is conveyed within is called *Absorption;* and the vessels conveying it are named *Absorbents.*

§ **24.** Anatomy of the Absorbents.—*The Absorbent Vessels. Distribution of the Lymphatics. The Thoracic Duct. The Lymphatic Duct. Position of Lymphatic Glands. Absorbent Veins.*

283. The Absorbents consist of certain blood-vessels, especially the venous capillaries and the absorbents proper, viz., *Lymphatic* Vessels* and *Glands.* The lymphatic vessels of the small intestines are named *Lac'teals.* †

284. The Lymphatic Vessels are distributed through most of the system. Few are found in the muscles, and none in the brain or spinal cord, though they doubtless exist there. They abound in the secreting membranes, especially in the skin and the mucous membrane.

The finer lymphatics unite into trunks, which either accompany the blood-vessels and form the *deep* lymphatics, or run on the surface of organs or in the sub-areolar tissue, forming *superficial* lymphatics. From all parts of the body, these trunks run toward the root of the neck and unite in two main trunks which end in the venous system, viz., the *Thoracic* and *Lymphatic Ducts.*

The lymphatics of the lower limbs, of the abdomen, of the

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* Lat., *lympha*, water. † Lat., *lac*, milk.

Fig. 87.

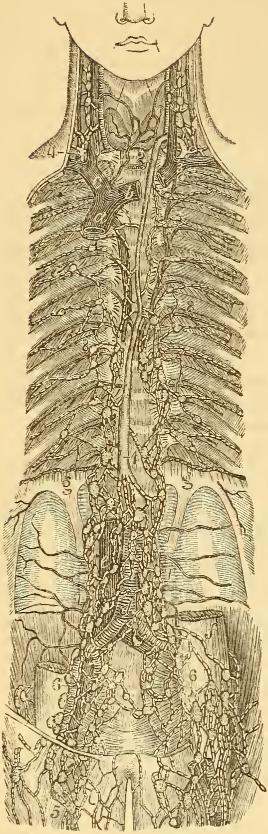

Fig. 87. View of the Great Lymphatic Trunks.—1, 2. Thoracic duct. 4, The right lymphatic duct. 5, Lymphatics of the thigh. 6, Iliac lymphatics. 7, Lumbar lymphatics. 8, Intercostal lymphatics. *a*, Descending cava. *b*, Left innominate vein. *c*, Right innominate vein. *d*, Aorta. *e*, Ascending cava.

left side of the head and neck and of the left upper limb form the *Thoracic Duct;* those of the right side of the head and neck and right upper limb form the *Lymphatic Duct.*

285. The Thoracic Duct commences with a dilatation, named the "Receptaculum Chyli," or receptacle of the chyle. This vessel is formed by the convergence of lymphatics from the lower extremities, the intestines, stomach, spleen, pancreas, kidneys and the greater part of the liver. The "receptaculum chyli" is usually placed upon the second lumbar vertebra, a little to the right of the aorta. It soon passes behind the arch of that vessel, crossing over the œsophagus, and ascends on the left side to the root of the neck, where it curves downward and outward behind the great blood-vessels, and finally opens into the angle at the junction of two large veins. (Fig. 87.)

286. The Lymphatic Duct is about an inch long, and has a similar termination on the right side of the body.

287. The Lymphatic Glands through which the vessels pass are somewhat

hard, pinkish bodies, varying in size from that of a hemp-seed to that of a large pea.

The lymphatic glands are found in the axilla of the arm (arm-pit) and in the groins; chains of glands are found on each side of the neck; a few in the arm; also many about the bronchi or air-tubes and in the pelvis or abdomen, those of the lacteals being abundant in the *Mes'entery.** (Fig. 87.)

288. The veins of the intestines acting as absorbents unite with those coming from the stomach, the spleen and the pancreas, thus forming the *Portal vein,* which enters the liver through a fissure in the concave surface. (Fig. 97.)

§ **25.** HISTOLOGY OF THE ABSORBENTS.—*Histology of the Lymphatic Vessels—Glands—Lymph.*

289. Most of the LYMPHATIC VESSELS are long, thread-like, transparent tubes, with coats so exceedingly delicate that their structure is a matter of inference from that of the Thoracic Duct, which has three coats, like the veins. The larger lymphatic tubes are liberally supplied with valves formed by the infolding of the inner coat. These valves are arranged in pairs, and are much more numerous in the smaller than in the larger vessels. A very strong pair is placed at the opening of the thoracic duct into the large vein. (Figs. 87, 89.)

290. The LYMPHATIC GLANDS are not well understood. They seem to be composed of a large number of vesicles or pouches, which communicate with each other, and also with the lymphatic tubes. These tubes or vessels, entering the gland, are called *afferent* vessels, and those emerging from it, *efferent* vessels. Each vesicle of the gland seems to connect with an afferent and an efferent vessel. (Fig. 90.)

291. The LYMPH consists of a fluid part containing nuclei, minute granules, and sometimes a few oily globules.

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* Gr., *mesos,* middle, and *enteron,* the intestine.

Fig. 88.

Fig. 89.

Fig. 90.

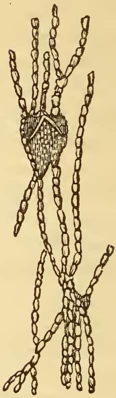


Fig. 88. A Single Lymphatic Vessel, much magnified.
Fig. 89. The Valves of a lymphatic trunk.
Fig. 90. A Lymphatic Gland, with several vessels passing through it.

§ 26. Chemistry of the Absorbents.—*Chemical Changes in the Absorbent System.*

292. We know little of the chemical changes which take place in the absorbent system; but the chyle drawn from the large absorbent trunks near their entrance into the "receptaculum chyli" is very different from that just absorbed by the lacteals. During its passage through these vessels and their glands it undergoes important alterations, assimilating it to the blood.

293. The following table, by Carpenter, gives the relative proportions of the three chief ingredients of the chyle in different parts of the absorbent system.

In the *Afferent Lacteals,* from the intestines to the mesenteric glands:

Fat in *maximum* quantity (numerous fat or oil globules). Albumen in *medium* quantity. Chyle-corpuscles, few or none. Fibrin almost entirely wanting.

In the *Efferent Lacteals,* from the mesenteric gland to the Thoracic Duct:

Fat in *medium* quantity. Albumen in *maximum* quantity. Chyle-corpuscles very numerous, but imperfectly developed. Fibrin in *medium* quantity.

In the Thoracic Duct:

Fat in *minimum* quantity (few or no oil-globules). Albumen in *medium* quantity. Chyle-corpuscles numerous, and more distinctly cellular. Fibrin in *maximum* quantity.

§ **27.** Physiology of the Absorbents—*Office of the Lymphatics. Absorbent Power of Different Tissues. Absorption in case of Disease. Imbibition of Animal Membranes.*

294. It was formerly supposed that the office of the Lymphatics was *excretive*—that of conveying from the system portions of waste matter no longer of use; but as these vessels are found to commence most frequently in tissues where nutritive changes are few—as there is a conformity in the nature of the fluids, chyle and lymph, the chief difference being due to the presence of fat and a large proportion of albumen in the chyle—as the two fluids are conveyed into the general current of circulation just before the blood is again transmitted into the system at large—the almost inevitable inference is that lymph, like chyle, is a *nutritious* fluid. There is much evidence that the lymph is obtained from the blood, and it is not improbable that the lymphatics take up those crude materials which were absorbed directly by the veins and subject them to an assimilating agency resembling that acting upon the nutritive substances in the lacteals.

295. The office of the lymphatics may also include another—assimilation. Disintegration of the tissues is everywhere taking place. Every respiration, every heart-beat, every muscular movement, every thought, is produced at the expense of the life of some of the tissues. The whole lymphatic system may be looked upon as one great assimilating or blood-making gland.

296. Different membranes have different absorbent powers, and the power of the same membrane varies with change of condition. The most active is the mucous membrane; thus, in the alimentary canal it takes up a large portion of the food; in the lungs it absorbs gases in a state of solution. In this way are introduced into the system miasmatic and contagious exhalations. Fine, solid particles are sometimes absorbed, as arsenic. Instances of poisoning are not uncommon among manufacturers of artificial flowers and green paper-hangings, arsenite of copper or "Scheele's green" being employed in the coloring.

297. Though much impeded by the cuticle, absorption takes place to a considerable extent through the skin, and the use of medicinal baths is based on this fact; shipwrecked sailors, destitute of fresh water, find that thirst is relieved by immersing the body in salt water. Life is sometimes supported for a time by immersing the patient in baths of milk or broth.

298. In serous and synovial membranes, the fluids poured out into the joint in rheumatism and other inflammations are absorbed. Absorption is shown in areolar tissue, as in taking up dropsical fluids; also by sub-cutaneous injections of a solution of morphia, to relieve suffering from neuralgic pain, from severe operations, obstinate cough and other irritations.

Observations.—1st, In cases of disease where no food is taken into the stomach, life is maintained by the absorption of fat. In consumption, even the muscles and more solid parts of the body are absorbed. 2d, Animals living in a half-torpid state during winter derive their nourishment from the same source.

299. There are no visible openings in the membranes for the passage of these absorbable substances, but their entrance seems to be effected by a peculiar action of animal membranes which enables certain fluids to pass directly through them by a kind of imbibition, a process called *endosmo'sis.**

* Gr., *endon*, within, and *osmos*, impulse.

§ **28.** Hygiene of the Absorbents.—*Conditions of Air affecting Absorption. Effect of Nutritious Food. Effect of the Removal of the Cuticle.*

300. *The air should be as free as possible from impure vapors and gases;* hence the importance of thorough ventilation, especially in the sleeping-room, since exhalations from the system are greater at night than by day.

Observation.—In infectious diseases the impure air should be constantly carried from the room, and the nurse should approach the patient *on the side* in which the currents of air are admitted.

301. *Moisture increases the activity of the absorbents;* hence, persons living in marshy districts contract miasmatic and contagious diseases more readily than those living in a drier atmosphere. In such localities the house should be plentifully supplied with fresh air and kept dry by the use of fires. Especially is this necessary morning and evening in spring and autumn, and often in summer.

Observation.—For the above reason the air of the sick-room should be kept dry; otherwise the poisonous exhalations are absorbed by the lungs and skin both of the *patient* and of the *nurse.*

302. *Nutritious food lessens the activity of the absorbents;* hence, in cases of infectious diseases due attention should be given to the food of the attendants and of the family. Some persons use alcoholic stimulants or tobacco "to prevent taking disease," but these increase the activity of the absorbents and the liability to contract disease. A moderate amount of nutritious food will be more efficacious.

Observation.—*In handling poisons care should be taken that the cuticle or skin be unbroken,* as absorption is very rapid when it is removed. In contagious diseases, if the skin is broken, it should be covered with adhesive plaster while at work over the patient. In handling dead bodies it is well to lubricate the hands with olive-oil or lard. The absorption of poisonous matter through a slight "scratch" or puncture of the cuticle, as the removal of a "hang-nail," has cost several valuable lives.

ANALYTIC EXAMINATION.

282. CHAPTER VII. ABSORPTION.—Define Absorption and Absorbents.

§ **24.** *Anatomy of the Absorbents.*—283. Of what do the Absorbents consist? Describe the Lacteals. 284. Where are the Lymphatic Vessels found? State the kinds of Lymphatics. How are the Thoracic and Lymphatic Ducts formed? 285. Speak of the Thoracic Duct. 286. Describe the Lymphatic Duct. 287. Describe the Lymphatic Glands. Where found? 288. What is the Portal Vein?

§ **25.** *Histology of the Absorbents.*—289. Describe the coats of the Lymphatic Vessels. With what are the larger Lymphatic Tubes supplied? 290. What is the supposed composition of the Lymphatic Glands? 291. Of what does Lymph consist?

§ **26.** *Chemistry of the Absorbents.*—292. What is said of chemical changes occurring in the absorbent system? 293. Give the proportions of the chief ingredients of Chyle in the Afferent Lacteals. In the Efferent Lacteals. In the Thoracic Duct.

§ **27.** *Physiology of the Absorbents.*—294. What is the office of the Lymphatics? 295. What may the office of the Lymphatics include? 296. Speak of the absorbing power of the mucous membrane. 297. Illustrate the absorbent power of the skin. 298. What is said of absorbent power of the serous and synovial membranes and the areolar tissue? Observations. 299. Describe Endosmosis.

§ **28.** *Hygiene of the Absorbents.*—300. What should be the condition of the air? Observation. 301. What influence has moisture? What care should be exercised by persons living in marshy districts? Observation. 302. What is the influence of nutritious food upon absorption? Of alcoholic stimulants, etc.? Observation.

Fig. 91.

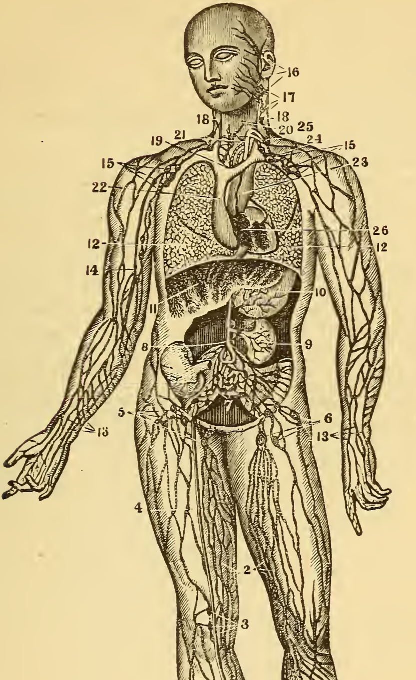


Fig. 91. A Representation of the Lymphatic Vessels and Glands.—1, 2, 3, 4, 5, 6, The lymphatic vessels and glands of the lower limbs. 7, Lymphatic glands. 8, The commencement of the thoracic duct. 9, The lymphatics of the kidney. 10, Of the stomach. 11, Of the liver. 12, 12, Of the lungs. 13, 14, 15, The lymphatics and glands of the arm. 16, 17, 18, Of the face and neck. 19, 20, Large veins. 21, The thoracic duct.

SYNTHETIC TOPICAL REVIEW.

Absorption, Absorbents, Vessels, Lymphatic Thoracic Duct, Lymphatic Duct, Lymphatic Glands, Absorbent Veins.	§ 24. *Anatomy of.*	Chap. VII. *The Absorbents.*
Lymphatic Vessels, " Glands, Lymph.	§ 25. *Histology of.*	
Absorbent System, Changes in	§ 26. *Chemistry of.*	
Lymphatics, Office of Membranes, Absorbent power of Absorption in disease, Imbibition of membranes.	§ 27. *Physiology of.*	
Condition of the air, Effect of nutritious food, " of removal of cuticle.	§ 28. *Hygiene of.*	

Give the Anatomy, the Histology, the Chemistry, the Physiology and the Hygiene of the Absorbent System of man.

CHAPTER VIII.

THE CIRCULATION.

§ 29. *The Blood. Composition of the Blood. Relation of the Absorbent System to the Blood.*

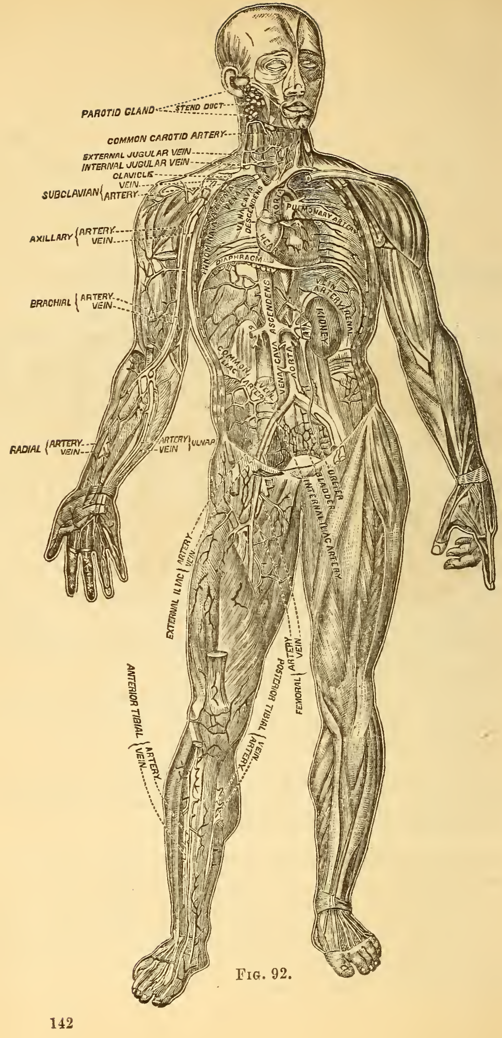
303. As the contents of the absorbent vessels enter the blood-vessels, they undergo their last complete change into that remarkable fluid, *the blood,* which contains all the materials for the support of every part of the animal fabric.

The blood consists of a liquid portion named *liquor sanguinis*—the *plasma* or liquor of the blood, which holds in suspension multitudes of minute circular bodies, called blood-corpuscles; these are of two kinds, the white or colorless, and the red; the latter are so minute that no less than one hundred millions are said to exist in a single drop of blood; the red color is due to their accumulation, as when in thin layers they appear yellowish. They contain only a slightly colored fluid, while the white corpuscles have, in addition, a nucleus and indistinct granules.

304. The blood is constantly undergoing loss, from supplying material for the secretions, for nutritive changes in the solid tissues, and also in the blood itself.

Observation.—The French call blood "chair coulant," *running flesh,* and with reason, since it not only contains the same constituents as flesh, but one-fifth of its weight is solid matter.

305. In order that the blood with its cargo of supplies should fulfill its mission of nutrition, it must be kept constantly moving in a circuit including every part of the body; this movement is called its *Circulation,* which takes place through the *Heart* and the *Blood-vessels,* which consist of the *Arteries, Capillaries* and *Veins.*



PAROTID GLAND
STENO DUCT
COMMON CAROTID ARTERY
EXTERNAL JUGULAR VEIN
INTERNAL JUGULAR VEIN
CLAVICLE
SUBCLAVIAN { VEIN ARTERY
AXILLARY { ARTERY VEIN
BRACHIAL { ARTERY VEIN
RADIAL { ARTERY VEIN
ARTERY VEIN } ULNAR
VENA CAVA DESCENDENS
AORTA
PULMONARY ARTERY
HEART
DIAPHRAGM
VENA CAVA ASCENDENS
VEIN ARTERY RENAL
KIDNEY
COMMON ILIAC ARTERY VEIN
VENA CAVA
AORTA
URETER
BLADDER
INTERNAL ILIAC ARTERY
EXTERNAL ILIAC { ARTERY VEIN
FEMORAL { ARTERY VEIN
POSTERIOR TIBIAL { VEIN ARTERY
ANTERIOR TIBIAL { ARTERY VEIN

Fig. 92.

§ 30. ANATOMY OF THE CIRCULATORY ORGANS.—*Construction of the Heart. The Arteries, Veins and Capillaries, and their Relation to each other. The Aorta and its Divisions. Arrangement of the Veins.*

306. The HEART is a hollow muscle enclosed in a sac, named *Pericardium.** In the male its proportion to the body is about 1 to 169; in the female, about 1 to 149. The heart is cone-like in shape, whence its triple division into base, body and apex. Its length is about five inches, and its basal diameter about four inches. It is everywhere free or

FIG. 93.

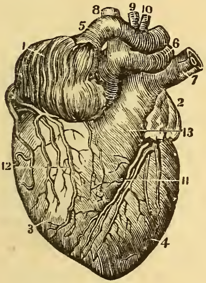


FIG. 94.

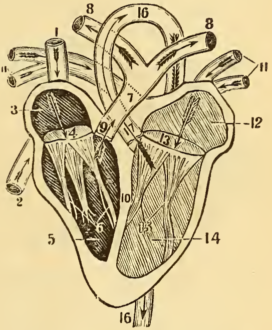


FIG. 93. A FRONT VIEW OF THE HEART.—1, The right auricle of the heart. 2, The left auricle. 3, The right ventricle. 4, The left ventricle. 5, 6, 7, 8, 9, 10, Vessels through which the blood passes to and from the heart.

FIG. 94. DIAGRAM OF THE HEART AND VALVES.—1, Descending vena cava. 2, Ascending vena cava. 3, Right auricle. 4, Opening between the right auricle and ventricle. 5, Right ventricle. 6, Tricuspid valves. 7, 8, Pulmonary artery. 9, Semilunar valves of the pulmonary artery. 10, Septum between the two ventricles of the heart. 11, 11, Pulmonary veins. 12, Left auricle. 13, Opening between the left auricle and ventricle. 14, Left ventricle. 15, Mitral valves. 16, 16, Aorta. 17, Semilunar valves of the aorta.

unattached excepting at the base, which by means of the large blood-vessels is joined to the vertebral column, reaching from the region of the fourth dorsal vertebra to the eighth. The apex is directed downward, forward and to the

* Gr., *peri,* about, and *kardia,* heart.

left, pointing to the junction of the fifth rib with its cartilage. The interior of the heart is divided by a longitudinal muscular septum or wall, into two chambers, named the right and the left chamber; each of these is divided by a transverse constriction into two apartments, named the *Au'ricle** and the *Ven'tricle*, the auricle occupying the basal end of the organ, and the ventricle the body and apex. There are virtually *two hearts* placed side by side, having no communication with each other and differing in function. The right division is sometimes called the *pulmonic* heart, and the left the *systemic* heart. (Figs. 92, 93, 94.)

Fig. 95.

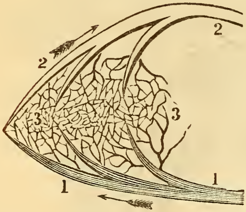


Fig. 96.

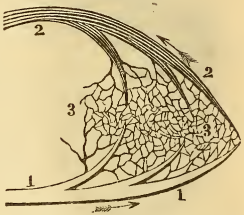


Fig. 95. An Ideal View of a Portion of the Pulmonic Circulation.—1, 1, A branch of the artery that carries the impure blood to the lungs. 3, 3, Capillary vessels. 2, 2, A vein through which red blood is returned to the left side of the heart.

Fig. 96. An Ideal View of a Portion of the Systemic Circulation.—1, 1, A branch of the aorta. This terminates in the capillaries (3, 3). 2, 2, A vein through which the impure blood is carried to the right side of the heart.

307. The Arteries are firm, membranous, cylindrical tubes, arising from the ventricles of the heart by two trunks; that from the left ventricle, named the *Aorta*, is the systemic trunk; and that from the right ventricle, named the *Pulmonic artery*, is the pulmonic trunk. (Fig. 94.)

308. The Aorta rises from the left ventricle for a short distance behind the sternum and then curves downward, forming a semicircular bend, called the *Arch* of the Aorta. It then passes downward, parallel with the spinal column,

* Lat., *auris*, an ear.

through the chest, and is given the name *Thoracic* aorta. In the abdomen it is named the *Abdominal* aorta. In the sacral part of the abdomen it finally separates into two divisions, called *Iliac* arteries. In the thigh, above the knee, its subdivision is named *Femoral;* below the knee, *Anterior* and *Posterior Tibial* arteries. From the Arch of the Aorta there are given off several large branches—the *Carotid,* which carries blood to the head; the *Subclavian:* its branches in the arm are named *Brachial;* below the elbow, *Radial* and *Ulnar* arteries. This systemic trunk (Figs. 92, 94) divides and subdivides into finer and finer arteries, like the branches from the trunk of a tree, excepting that these branches communicate with each other in a finer network, till the ultimate ramifications, too minute to be seen by the naked eye, extend to every nook and corner and atom of the body. These final branches are called *Capillaries.*

309. The CAPILLARIES serve to connect the termination of the arteries with the beginning of the *veins,* so that it is impossible to tell just where the artery ends and the vein begins. In these minute vessels the blood comes in intimate contact with the substance of the tissues, making them the most important part of the whole circulatory system. (Figs. 95, 96.)

310. The VEINS thus commencing with the capillaries unite into larger and larger veins, converging *toward* the heart till the final union in two trunks, the *Ascending* and *Descending Venæ Cavæ,* that connect with the right auricle of the heart. The *Ascending Vena Cava* collects the blood from the lower extremities, pelvis and abdomen, and terminates in the right auricle of the heart. (Fig. 92.) The *Descending Vena Cava* derives its branches from the head, neck, upper extremities and walls of the thorax. It terminates at the upper back part of the right auricle of the heart. The Aorta and Cavæ constitute the large vessels of Systemic or General Circulation. (Figs. 92, 103.)

311. The *Pulmonary Veins* are four in number, two for each lung. They commence with the capillaries of the lungs, and

converge till a single trunk is formed for each lobe, or three trunks for the right lung and two for the left; but the trunk from the middle lobe of the right lung joins that from the upper lobe of the same side, and the four mouths discharge into the four angles of the left auricle. The Pulmonary Artery which arises from the right ventricle of the heart, and is distributed to the lungs, together with the pulmonary veins, constitute the Pulmonic or Lesser Circulation.

Fig. 97.

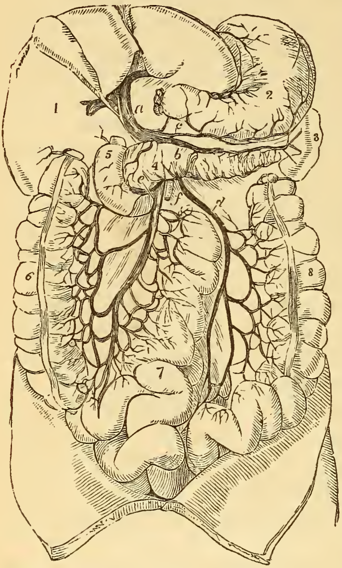


Fig. 97. The Portal System of Veins.—*a*, Portal vein. *b*, Splenic vein. *c*, Right gastro-epiploic vein. *d*, Inferior mesenteric vein. *e*, Superior mesenteric vein. *f*, Trunk of the superior mesenteric artery. 1, Liver. 2, Stomach. 3, Spleen. 4, Pancreas. 5, Duodenum. 6, Ascending colon; the transverse colon is removed. 7, Small intestine. 8, Descending colon.

312. The *Portal Vein,* so called because it enters the Liver by a kind of fissure or gateway upon its under surface, is a short trunk about three inches in length, derived from the convergence of the veins of the stomach, spleen, pancreas and intestines; this passes into the liver, where it divides and sub-divides, being distributed throughout the organ. This blood, with that of the *Hepat'ic** artery, is returned to the general circulation by the hepatic veins. (Fig. 97.)

* Gr., *hepar*, the liver.

§ **31.** HISTOLOGY OF THE CIRCULATORY ORGANS.—*The Pericardium and Endocardium. The Valves of the Heart. The Muscular Structure of the Heart. The Coats of the Arteries—Of the Veins—Of the Capillaries.*

313. The PERICARDIUM or heart-case is composed of two layers, one fibrous and the other serous. The *fibrous* layer forms a loose sac over the heart, being connected only at the base, from which it embraces the several blood-vessels, and becomes continuous with their external coats. The *serous* layer closely invests the heart, and also the great blood-vessels at its base, from which it is reflected to line the fibrous layer of the pericardium. (Fig. 98.)

FIG. 98.

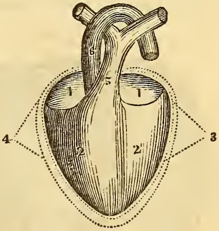


FIG. 98. DIAGRAM OF THE HEART WITH ITS INVESTMENT.—1, 1, Right and left auricles. 2, 2, Right and left ventricles. 3, 4, Pericardium. 5, Pulmonary artery. 6, Aorta.

314. The ENDOCARDIUM or lining membrane of the heart is a thin, translucent membrane continuous with the inner coats of the blood-vessels. It consists of an epithelium, an exceedingly thin basement membrane and a fibro-elastic layer closely adherent to the general muscular structure beneath. At the opening between the auricles and ventricles, at the commencement of the aorta and of the pulmonary artery, the fibro-elastic tissue forms four wings sometimes called *fibrous zones.* It also forms valves by its little folds, enclosing muscular fibres. Those at the openings of the aorta and the pulmonary artery are named, from their shape, *Semi-lunar* valves. They form complete pockets, three in number, and have a triangular arrangement about the orifices. Behind each of these valves is a cavity or pouch in the artery.

315. Between the auricles and ventricles are valves also formed by foldings of the endocardium. On the left side are two, named *Mitral* valves. They form a kind of curtain, from

whose floating edge small white cords (*chordæ tendinæ*) pass to some of the fleshy columns (*columnæ carnæ*), thus preventing the edge from being carried into the auricle. On the right side are three valves formed of three folds of membrane, called the *Tri-cuspid* valves. (Fig. 94.)

316. *The muscular structure of the heart* is based upon the four fibrous zones, which furnish a point of departure for most of the muscular fibres in the ventricles. Those of the auricles and of the ventricles are quite independent of each other. The crossing fibres form networks arranged in three circular plates, the superficial, middle and internal. The

Fig. 99.

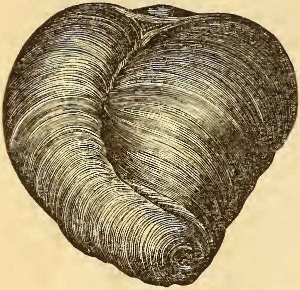


Fig. 100.

Fig. 99. Spiral and involuted arrangement of the fibres of the heart.
Fig. 100. Gyration of the fibres of the heart at the apex.

superficial fibres commence at the base, and pursue a spiral course to the apex; those of the right side running from right to left; those of the left side, from left to right. These two spiral sets encircle the apex and cross each other somewhat like the lines in the figure 8, thus forming a remarkable whorl. (Figs. 99, 100.)

Observation.—It is computed that not less than six tons of blood traverse the blood-vessels daily. The force required to expel this amount to different parts of the body often causes disease of the heart and its valves. The heart may become enlarged or its walls may be softened or thinned. The valves may become cartilaginous or ossified, or even broken. Not unfrequently the irregular action of the heart is sympa-

thetic. Whenever the heart or its valves are disorganized, the movements should be slow, the skin kept clean and protected by warm, porous clothing, and the food and drink unstimulating and taken in moderate quantities.

317. The ARTERIES have three coats continuous with the endocardium and the fibrous coat of the pericardium. The external coat is chiefly of white fibrous tissue; it is quite thin in the aorta and larger trunks, and disappears entirely in the smaller vessels. The middle coat is thick in the large arteries, and gradually becomes thinner till its disappearance before reaching the capillaries. The inner coat is thinnest and most elastic; like the endocardium, it has an epithelium, a basement membrane and a layer of connective elastic tissue. The latter is intimately connected with the middle coat.

318. The CAPILLARIES are exceedingly delicate tubes, which are continuous with the basement membrane of the internal coat of the arteries and veins. The network of the capillaries varies, adapting itself to the particular tissue in which it is found; thus, in the lungs it takes the form of the air-cells; in the muscles the meshes are elongated. The important operations of secretion and the conversion of the nutrient materials of the blood into bone, muscle, etc., are performed in these vessels. (Figs. 95, 96.)

FIG. 101.

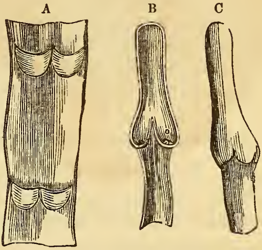


FIG. 101. DIAGRAMS EXHIBITING THE ARRANGEMENT OF THE VALVES OF VEINS.—A, Vein laid open, showing the valves in pairs. B, Longitudinal section of a vein, indicating the mode in which the valves, by apposition of their free edges, close its calibre. The dilated condition of the walls behind the valves is also seen. C, Vein distended, showing how the sinuses behind the valves become dilated.

319. The VEINS are constructed, in general, like the arteries, but their coats are much thinner. Many of the larger veins, particularly in the limbs, have crescent-shaped valves,

usually arranged in pairs and opposite each other. These are formed by the doublings of the lining membrane, strengthened with intervening fibro-elastic tissue. Behind each valve there is a dilatation of the vein, forming a little pouch. (Fig. 101.)

The veins are arranged in two sets—the superficial and the deep-seated; the former lie immediately under the skin, possessing no corresponding arteries; the deep-seated veins directly attend the arteries, and usually take the same name. The largest arteries have one venous trunk; the medium-sized have two, called *venæ comites*. The walls of both arteries and veins are furnished with *nutritive* vessels and with nerves.

Observation.—The action of the heart is independent of the Will. Anger or sorrow may disturb the regularity of its motions, and various emotions may so affect its action as to produce faintness, but ere long it resumes its pulsation. The ordinary contraction or *pulse* in mature life is about seventy-five in a minute. It is one of the remarkable instances of adaptation in the system, that the heart is so sensitive to the slightest changes in the state of the blood that its mode of contracting and its frequency indicate the existence of disease in its first stages, and yet the heart itself is not sensible in any degree to external contact.

§ **32.** Chemistry of the Blood.—*Analysis of the Blood.*

320. The analysis of blood by different chemists gives very different results, due chiefly to the variable composition of this fluid under different conditions connected with health, age, temperament, etc. The following table from Lehman shows the composition of 1000 parts of blood, calculated from the analysis of venous blood by Lecanu:

	Corpuscle.	Plasma.	Total.
Water	344.000	451.45	795.45
Hæmatin	8.375	......	8.375
Globulin	141.11	......	141.11
Fat	1.155	.86	2.015
Extractive matter	1.3	1.97	3.27
Salts	4.06	4.275	8.335
Fibrin	......	2.025	2.025
Albumen	......	39.42	39.42
	500.000	500.000	1000.000

321. According to this estimate, blood contains about eighty per cent. water and twenty per cent. solid matter.

Blood charged with gases, especially oxygen, nitrogen and carbonic acid, has a saline taste, and is an alkaline fluid. When blood is exposed to the air, the fibrin coagulates, carrying down with it mechanically the corpuscle; this leaves an amber-like fluid called serum, in which the solid part or clot floats.

§ **33.** Physiology of the Circulatory Organs.—*Necessity for Circulation—For the Double System of Circulation. Plan of Systemic Circulation—Of Pulmonic Circulation—Their Relation to Each Other. Provisions necessary in a Circulatory Apparatus. The Circulatory Impulse. Prevention of a Re-flow. Additional Forces for maintaining the Current in the Arteries—In the Veins. Equalization of the Current. Supply of a due Proportion to each Organ. Provision for Contingencies.*

322. The tissues are so constructed that their vitality depends upon their activity, and their activity upon the amount of oxygen and nutritive material supplied, the oxygen being essential to the chemical combinations, without which there could be no new deposit of tissue particles, and also to furnish a stimulus, especially to the nervo-muscular system, and the nutritive matter being necessary to supply the waste produced by these chemical and vital activities; hence the necessity of a pneumatic apparatus for providing a constant and sufficient supply of oxygen, and of a hydraulic apparatus for conveying the prepared nutriment to every atom of the body, and also to remove the waste, worn-out particles. The former need is met by the exquisite mechanism of the lungs, and the latter by the no less refined mechanism of the heart and blood-vessels. The two apparatuses are brought into use and harmonious co-working by the *double circulation* of the blood, hence the necessity of the double heart. (Figs. 102, 103.)

323. From the left ventricle the blood is forced into the aorta, to be diffused through the arteries to the capillaries in every part of the body; thence it is returned by the veins, through the venæ cavæ, to the right auricle, which delivers it to the right ventricle; this completes the *Systemic Circula-*

tion. From the right ventricle it is thrown into the pulmonary artery, and through its branches to the pulmonary capillaries, thence returned by the pulmonary veins, which coalesce into four trunks, and finally enters the left auricle, which immediately pours it into the left ventricle. This completes the *Pulmonic Circulation,* and the two constitute one complete circuit of the double circulation. (Figs. 103, 105.)

FIG. 102.

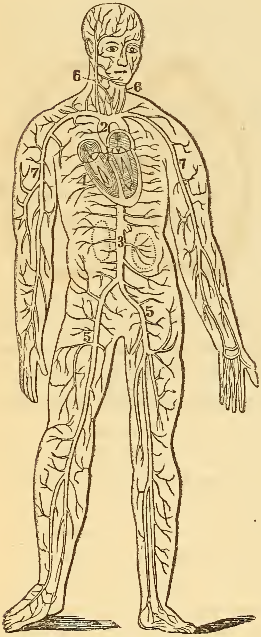


FIG. 103.

FIG. 102. A DIAGRAM.—1, Left ventricle of the heart. 2, 3, Aorta. 5, 5, Arteries that extend to the lower extremities. 6, 6, Arteries of the neck. 7, 7, Arteries of the arms.

FIG. 103. A DIAGRAM.—1, Right auricle of the heart. 2, 3, Large veins that open into the right auricle. 4, 4, Veins of the lower extremities. 5, 5, Veins of the arms. 6, Veins of the neck. The arrows show the direction that the blood flows.

324. Both circulations are carried on at the same time—that is, the auricles contract and dilate simultaneously; the same is true of the ventricles, whose action immediately follows that of the auricles. Hence, at the same instant, by the action of the ventricles, pure blood is thrown into the body, and impure blood into the lungs; and at the same instant the auricles receive impure blood from the body, and pure blood from the lungs.

Fig. 104.

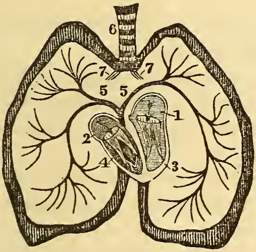


Fig. 105.

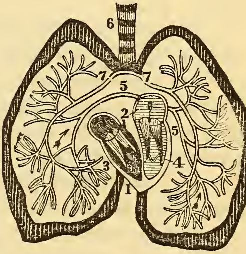


Fig. 104. A Diagram.—1, Left auricle. 2, Right auricle. 3, Left ventricle. 4, Right ventricle. 5, 5, Pulmonary artery. 6, Trachea.

Fig. 105. A Diagram.—1, Right auricle. 2, Left auricle. 3, Right ventricle. 4, Left ventricle. 5, 5, Right and left pulmonary veins. 6, Trachea.

325. How to construct and keep in successful operation an apparatus which should secure the free circulation of the blood was no easy mechanical problem. 1st, It was necessary to provide the requisite motor-power at the starting-point; 2d, to prevent a backward flow; 3d, to protect the arteries against the force of the heart; 4th, to maintain a ceaseless current; 5th, to equalize the pressure, especially in the capillaries; 6th, to ensure the proper relative quantity of blood to each organ; and 7th, to provide for contingencies arising from accident or other abnormal action.

326. 1. For giving the proper circulatory impulses, we find in each heart, instead of a single cavity, the auricle and ventricle, affording a far more powerful impulse. The walls

of the ventricles are thicker than the auricles, and the left ventricle is thicker than the right; also the peculiar spiral and circular arrangement of the muscular fibres of the ventricles is most effective in producing the greatest projectile force. Here comes in a beautiful example of the adaptation of each part to its destined use.

2. A retrograde flow of blood is prevented by the valves of the heart and those of the blood-vessels communicating with the heart, and by the contraction of the muscular columns of the ventricles and also the little cords of the valves.

3. The arteries are protected against the sudden action of the heart by the elastic fibres of their middle coat.

4. The respiratory movements, the smooth surface of the inner arterial coat, the elastic and muscular character of the fibres of the middle coat of the arteries, aid in the maintenance of the circulatory current.

5. The intermittent pressure caused by the action of the heart is equalized by the elastic coat and also by the anastomosing or branching of the arteries.

6. The proper amount of blood to each organ is secured by the adaptation of the size of the artery to the need of the part. Within certain limits, arteries are susceptible of variation, and the supply of blood may be in some measure regulated by their contractility.

7. Contingencies are also provided for, by the frequent anastomoses of the arteries, by their capability of distension, and also by their capability of positive enlargement by the increased nutrition of their walls. Hence, though obstructions should exist in a blood-vessel, the organ may be measurably supplied with blood by lateral channels.

327. The flow through the veins is continued by the combined action of several forces—viz., the capillary impulse: the movement of the blood in these microscopic tubes is steady and incessant; the suction-power of the dilating auricles, drawing the blood to the heart; the presence of valves, single in the small veins, double in the larger trunks, and some-

times composed of three flaps; and the thoracic respiratory movements.

Observation.—Though our knowledge is so imperfect, our tracing so indistinct, our souls must be dead indeed if they do not respond to the exclamation of him of old, "I am fearfully and wonderfully made"—fearfully, for often, as in the heart-valves, there is but a gossamer web, a tendinous cord, between the life here and the life beyond; wonderfully, for in all the rounds of human art we find nothing which can at all compare, in perfect simplicity, in faultless skill, in matchless beauty, in the refinements of philosophy and in the subtleties of chemistry, with this vital workmanship which can be none other than that of God. Till we reach our utmost range of vision, it is ever the same unfolding of the care, the wisdom, the benevolence of Him to whom nothing is great and nothing small; and beyond our finiteness, His eye alone surveys the work of busy legions of artificers, ever building up what the wear and tear of life are ever breaking down; His ear alone listens to the music of the million life-rills as they murmur on in their ever-ceaseless flow.

§ **34.** HYGIENE OF THE CIRCULATORY ORGANS.—*Conditions favoring Free Circulation. Treatment of Divided Arteries.*

328. *A natural and equal temperature should be preserved.* The blood-vessels are contracted by cold, hence a chill in any part of the body drives the blood to other parts. The chilled part is thus weakened, while the over-burdened parts suffer from congestion. If the surface is chilled, the blood is thrown upon the internal vital organs; hence the necessity of warm clothing, and also frequent bathing, which favors the free action of the cutaneous vessels.

329. *The clothing should be loosely worn.* Compression of any kind impedes free circulation. Pressure about the vital organs is especially injurious. Ligatures used to retain in place any article of apparel should be elastic. Tight dressing of the neck deprives the brain of its due amount of blood, and retards the free return of venous blood from this organ—an item of particular importance to students, public speakers and persons predisposed to apoplexy or any brain disease.

330. *Exercise promotes the circulation of the blood.* By the action of the muscles the blood is propelled more rapidly through the blood-vessels, thus promoting a vigorous circula-

tion in the extremities and skin. The best stimulants for a pale skin and cold extremities are a union of vigorous muscular exercise with agreeable mental action, and systematic bathing attended by thorough friction.

331. *The quality and quantity of the blood modify the action of the heart and blood-vessels.* If this fluid is abundant and pure, the circulatory vessels act with more energy than when it is deficient in quantity or defective in quality. (See Digestive and Respiratory Organs.)

Observation.—If blood in large quantities is drawn from the veins, the heart will beat feebly and the pulse become weak. A similar effect is produced when the blood becomes vitiated by the inhalation of impure air.

§ **35.** COMPARATIVE ANGIOLOGY.—*Circulation of the Blood of Reptiles, of Amphibians, of Mollusca, and of Insects. Other Mammals, of Birds, compared with the same in Man.*

The blood of *Mammals* is red, and the globules generally round. In some Mammals, as the Camel, they are elliptical. The hearts of Mammals have two auricles and two ventricles.

FIG. 106.

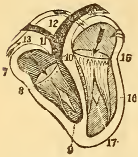


FIG. 107.

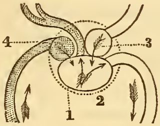


FIG. 108.

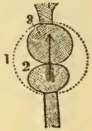


FIG. 106. DIAGRAM OF THE HEART OF THE MAMMAL.—7, Right auricle. 8, Right ventricle. 10, Pulmonic artery. 12, Pulmonic vein. 15, Left auricle. 16, Left ventricle.

FIG. 107. DIAGRAM OF THE HEART OF THE REPTILE.—1, Pericardium. 2, Single ventricle. 3, Left auricle. 4, Right auricle. The arrows show the direction of the blood.

FIG. 108. DIAGRAM OF THE HEART OF THE FISH.—1, Pericardium. 2, The ventricle that receives the blood from the body. 3, The ventricle that sends blood to the gills.

The heart in quadrupeds lies on the median line of the body, and not a little to the left of it, as in man. There is a marked peculiarity in the distribution of the arteries of quadrupeds. In the long necks of grazing animals there is found a large number of small arterial trunks, which are termed "Wonder

Nets." Were these trunks few and large, as in man, the life of the animal would be endangered by the constant dependent position of the head.

332. The blood of *Birds* has the highest temperature of the vertebrate animals. It is richer in globules than in man, and these corpuscles are elliptical. The heart of birds is highly muscular, and of large size in proportion to the bulk of the body. The aorta, at its commencement, divides into three large branches, of which the first two convey the blood to the head and neck, wings, and muscles of the chest; while the third, curving downward around the right bronchus, becomes the descending aorta. There are "Wonder Nets" in various parts of the body, especially in the arteries supplying the brain, eyes and legs.

Fig. 109.

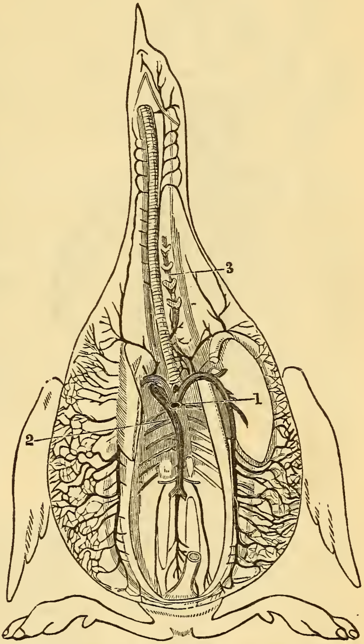


FIG. 109. ARTERIES OF THE TRUNK OF A BIRD (the Grebe). —1, The aorta. 2, The vena cava. 3, A cerebral artery. The small lines on each side represent the arteries and veins of the lungs.

333. In *Reptiles* the blood is cold, that is, only slightly

warmer than the temperature of the external medium in which they live, having fewer globules and lighter in color.

Fig. 110.

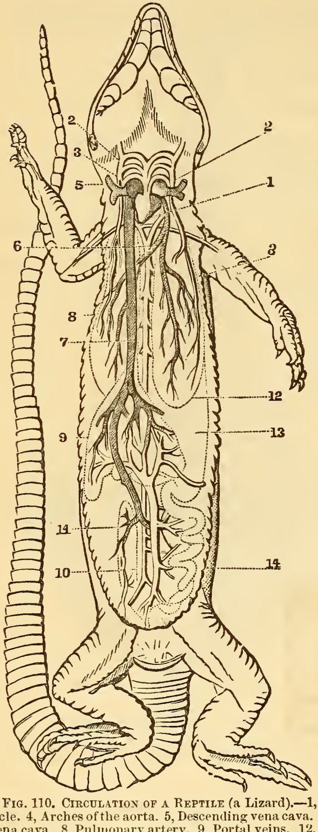


Fig. 111.

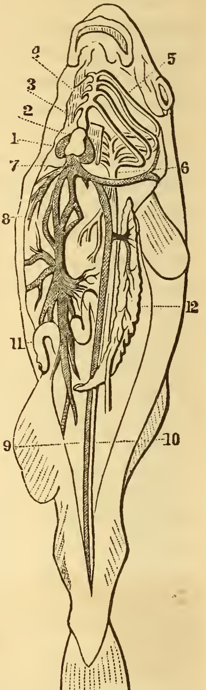


Fig. 110. Circulation of a Reptile (a Lizard).—1, Heart. 2, Left auricle. 3, Right auricle. 4, Arches of the aorta. 5, Descending vena cava. 6, 10, Abdominal aorta. 7, Ascending vena cava. 8, Pulmonary artery. 9, Portal veins. 12, Lungs. 13, Stomach. 14, Intestines.

Fig. 111. Blood-Vessels of a Fish.—1, Auricle. 2. Ventricle. 3, Arterial bulb. 4, Bronchial artery (gill). 5, Bronchial vessels. 6, 10, Dorsal artery. 7, Venous sinus. 8, Portal vein. 9, Vena cava. 11, Intestines. 12, Kidneys.

The heart consists of two auricles and one ventricle. The arterial blood coming from the lungs is received into the left auricle, and the venous blood from all parts of the body into the right auricle; both are poured into the single ventricle, thus mixing the pure and impure blood, which will account for the sluggishness of these animals. A portion of this mixture returns by the aorta into the different organs it is intended to nourish, while another part proceeds to the lungs by vessels springing from the ventricle or the aorta. (Fig. 107.)

334. The *Amphibians* are cold-blooded animals. The blood-corpuscles are larger than in mammals. Their circulation is incomplete.

335. In *Fishes* the blood is cold, usually red, and the corpuscles small and bi-concave. The heart has one auricle and one ventricle, containing only impure blood; this blood is sent to the *gills*, which answer the purpose of lungs, and after being there exposed to the oxygen of air contained in the water and purified, it is distributed immediately to the different parts of the body, without the interposition of a heart. From the body the blood is returned to the auricle.

336. The circulation of Lobsters and Crabs, etc., is similar to the Mollusca. The heart consists of a single ventricle, and the veins are everywhere replaced by irregular cavities, called venous sinuses.

Fig. 112.

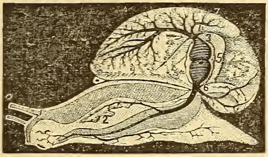


Fig. 113.

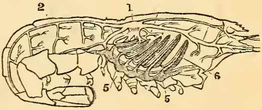


Fig. 112. The Heart and Arteries of a Snail.—2, The Stomach. 3, Intestines. 5, Heart. 6, Aorta. 7, Pulmonary artery.

Fig. 113. The Heart and Arteries of a Lobster.—1, The heart. 2, The abdominal artery. 5, 5, Venous sinuses. 6, The branchia from which the blood returns to the heart.

337. In most of the Mollusca the circulation resembles

that of fishes. The heart has usually a ventricle, whence spring the arteries and one or two auricles which carry the arterial blood from the respiratory apparatus which this liquid reaches by venous tubes more or less complete.

Fig. 114.

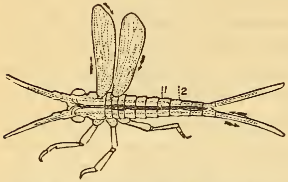


Fig. 114. Diagram of the Circulation of an Insect.—1, Dorsal vessels in which the blood flows. 2, The lateral currents. The arrows show the outward and the inward current.

338. Insects have neither arteries nor veins. The circulation, such as it is, is animated by the action of a vessel called dorsal, which is situated above the digestive tube.

Observations.—"In worms (as the leech and earth-worm) there exists a complete vascular apparatus, but generally no heart; the blood is set in motion by movements of the vessels themselves, and hence the circulation of the blood is irregular.

"In polyps there exists a kind of circulation produced by the action of the vibratile cilia with which the walls of the cavity, acting at once as stomach and intestines, are provided; by means of these cilia the contained liquids are kept constantly in motion. This cavity is sometimes single, but in some it sends branches to various parts of the body."

ANALYTIC EXAMINATION.

Chapter VIII.—The Circulation.

§ **29.** *The Blood.*—303. From what source is the blood derived? Of what does the blood consist? 304. For what purpose is the blood constantly undergoing loss? Observation. 305. Why must the blood be kept in circulation? Name the Circulatory Organs.

§ **30.** *Anatomy of the Circulatory Organs.*—306. Describe the Heart. 307. What are the Arteries? 308. From what part of the heart arises the Aorta? Give its name and branches. 309. Describe the capillaries. 310. Give the course of the Veins. What constitutes the large vessels of the Systemic Circulation? 311. Describe the Pulmonary Veins. What constitutes the Pulmonic Circulation? 312. Describe the Portal Vein.

§ **31.** *Histology of the Circulatory Organs.*—313. Of what is the Pericardium composed? 314. What can you say of the Endocardium? Where does the fibro-elastic tissue form four rings? Where are the Semilunar valves? 315. Where are the Mitral valves? Where the Tricuspids? 316. Upon what is the muscular structure of the heart based? What is said of the superficial fibres? Observation. 317. Name and describe the coats of the arteries. 318. Give the structure of the Capillaries. 319. How are the veins constructed? Describe the valves in the veins. How are the veins arranged? Observation.

§ **32.** *Chemistry of the Blood.*—320. State the analysis of the blood. 321. What per cent. of solid matter and water in the blood? When the blood is exposed to the air, what changes take place?

§ **33.** *Physiology of the Circulatory Organs.*—322. Why is circulation necessary? Why a double heart? 323. Give the Systemic circulation; the Pulmonic. 324. What is said of the contraction and dilatation of the auricles and ventricles? What is the effect of such action? 325. In the construction of the circulatory system, what was necessary? 326. By what means are proper circulatory impulses given? How is a retrograde flow of blood prevented? How are the arteries protected against sudden action of the heart? How is the current maintained? How is the intermittent pressure caused by the action of the heart equalized? What secures the proper amount of blood to each organ? What provision is there for contingencies? 327. How is a continuation of the flow through the veins affected? Observation.

§ **34.** *Hygiene of the Circulatory Organs.*—328. What temperature should be preserved? 329. Why should the clothing be worn loosely? 330. What is the influence of exercise on circulation? 331. What is said of the quality and quantity of the blood? Observation.

§ **35.** *Comparative Angiology.*—332. What is said of the blood and circulatory organs of Mammals? 333. Of Birds? 334. Of Reptiles? 335. Of Amphibia? 336. Of Fishes? 337. Of Lobsters? 338. Of Mollusca, etc.? 339. Of Insects?

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[Compare 303 with 294–299 and 239–243.]

Give in full the changes in food during Primary Assimilation.

[Compare 304 with 340–346.]

How does the blood contribute to the growth of the different parts of the body?

[Compare 305 with 306–312.]

Name and describe the organs by which the blood effects this contribution.

[Compare 306 with 332–339.]

Compare the heart of man with that of other mammals, and with those of Birds, etc.

[Compare 307–312 with 333–339.]

Compare the blood-vessels in the different classes of animals.

[Compare 328–331 with 184, 185, 194, 195, 247–256, 445 and 519–532.]

What conditions favor free circulation? What can you say of the food in this connection? How is exercise essential to the health of the nervous tissue? In connection with circulation, what is said of clothing and bathing?

SYNTHETIC TOPICAL REVIEW.

Blood, its circulation, " loss of, Circulatory Organs.	§ 29. *The Blood.*	**Chap. VIII.** *The Circulatory Organs.*
Heart, Arteries, Aorta, divisions of, Capillaries, Veins, Ascending Vena Cava, Descending " Pulmonary Veins, Portal Vein.	§ 30. *Anatomy of.*	
Pericardium, Endocardium, Valves of the heart, Muscular structure of the heart, Arteries, their coats, Capillaries, " Veins, "	§ 31. *Histology of.*	
Analysis of the blood.	§ 32. *Chemistry of.*	
Necessity of double circulation, Systemic Circulation, Pulmonic Circulation, Their relation to each other, Necessary provisions, Circulatory impulse, Prevention of a retrograde flow, Protection of the arteries, Current maintained, Equalization of the current, Due supply to each organ, Provision for contingencies, Flow through the veins.	§ 33. *Physiology of.*	
Conditions favoring free circulation.	§ 34. *Hygiene of.*	
Mammals, circulation of the blood of Birds, " " Reptiles, " " Amphibians, " " Fishes, " " Lobsters, " " Mollusca, " " Insects, " "	§ 35. *Comparative Angiology.*	

Give the Anatomy of the several parts of the Circulatory System, Human and Comparative, the Histology, the Chemistry, the Physiology and the Hygiene.

Fig. 115.

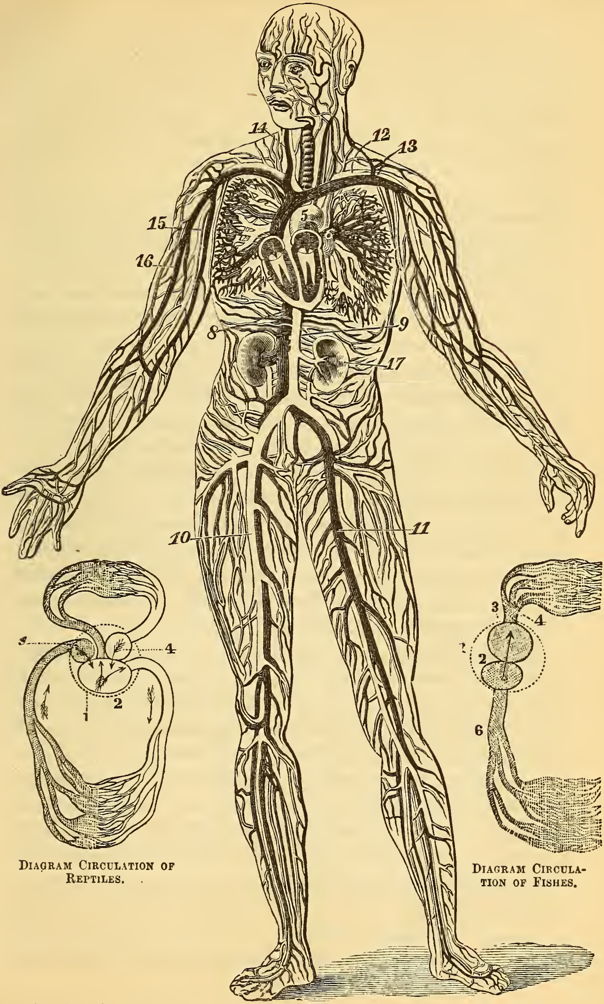

Diagram Circulation of Reptiles.

Diagram Circulation of Fishes.

Fig. 117.—3, 4, Heart. 5, Aorta. 6, Pulmonary artery. 7, Descending cava. 8, Ascending cava. 9, Abdominal aorta. 10, Femoral artery. 11, Femoral vein. 12, Subclavian artery. 13, Subclavian vein. 14, Carotid artery and vein. 15, Brachial artery. 16, Brachial vein. 17, Kidney.

CHAPTER IX.

ASSIMILATION.

§ **36.** *Assimilation, General and Special. Changes included under Secondary Assimilation. Secretion, or Special Assimilation. Excretion, characteristic of all Secretory and Excretory Glands. The Kidneys.*

339. In the human body, as elsewhere, the essential condition of physical *life* is *death.* While the vital force holds the mastery over the chemical forces, the more frequent the death-knell of the particles, the more abounding is the life. They perform their mission, yield up their vitality and pass away, while their places are supplied with new material. This new material is obtained from the food after its proper assimilation. As before stated, the processes by which food is converted into chyle, and then into blood, may be included under *Primary Assimilation,* while the changes which convert portions of the blood into solid tissue may be termed *Secondary Assimilation;* both of these we will include under the head of *General Assimilation,* and the processes of secretion under *Special Assimilation.*

340. Secondary Assimilation, or Nutrition of the Organs and Tissues, consists of the following stages: *First,* A nutritive fluid or plasma exudes from the blood, through the coats of the capillaries, filling the finest interstices of the tissues between the capillary networks, and bathing all the elementary parts of these tissues. The nature of this plasma is the same in all parts of the system, and it is sometimes thought to be identical with the liquor sanguinis of the blood, but this is doubtful; it is more probable that the exuded plasma destined for the nutrition of the tissues is of a purer nutrient material.

Second, The nutritive process consists in the exercise of a certain selective act by the elementary parts of tissues and

organs, enabling them to appropriate to themselves such portions of the nutritive fluid as are suitable, either with or without further change, to renew, molecule by molecule, their worn-out substance. "The nucleated cells of the epithelium and epidermis, the corpuscles of the gray matter of the brain, the tubular fibres of the white nervous tissue, the complex fibres of the striated muscles, the simple fibrous forms of the contractile non-striated muscles, the fibres of the fibrous and areolar tissues, and lastly, the consolidated substance, with the remnants of cells imbedded in it, as in cartilage and bone,—each derives from the exuded plasma of the blood, and assimilates its required constituents."

Third, The result of the act of assimilation is to leave a residual fluid in the interspaces of the tissue-elements outside the capillary vessels. The nature of this fluid must differ in the different tissues, inasmuch as different tissues make different appropriations.

Fourth, The final residue of the exuded plasma—that which is not taken up by the tissues nor lymphatics—is probably taken up by the venous capillaries.

Fifth, With the final residuum are mingled the effete particles of waste from the tissues, which also enter the venous blood, through the walls of the venous half of the capillaries and of the minute veins. These processes, though separately described, are, of course, in the living body, all going on at the same time, and continuously, and, in a healthy condition, with a perfect balance of action.

341. Nutrition not only supplies the waste, but in *new growth,* new cell-elements, or germinal centres, are constantly reproduced and developed. This process occurs, after the body has attained maturity, in the epidermis, nails, hair, the epithelial tissues, and probably the gray nervous substance, and perhaps in some of the other tissues.

342. Special Assimilation or Secretion is the separation from the blood of materials in a more or less fluid condition, through a *gland* or *membrane.* After assimilation or secretion, the products are discharged from the ducts of the glands

or the surfaces of the membranes, and are used for certain purposes in the living economy or eliminated from the system.

343. The secreting glands are the liver, the pancreas, the salivary and the lachrymal glands; the true mucous glands of the nose, mouth, fauces, pharynx, œsophagus, duodenum and those of the skin; the simple tubular glands of the stomach and intestines; the sebaceous and the mammary glands. The secreting membranes are the mucous, serous and synovial membranes.

344. EXCRETION is effected by glands only, and the *educts* are eliminated from the blood and thrown out of the system. The excretory glands are the kidneys, the sweat glands of the skin, to a certain extent the liver, and perhaps the intestinal tubuli, especially of the large intestine, also the sebaceous glands of the skin, and lastly, the lungs, which eliminate carbonic acid from the blood.

345. In all cases of Secretion and Excretion there is invariably found, even in the ultimate ramifications of the gland-ducts, a basement membrane covered by a layer of epithelial cells. All glands are very vascular, and receive large quantities of blood. In many secretory processes the epithelial cells are ruptured, and their contents, and sometimes the cells themselves, escape as an essential part of the secretion itself, as in the saliva, pancreatic fluid, gastric juice, the sebaceous and mucous secretions, and perhaps the bile.

346. The KIDNEYS lie one on each side of the spinal column, in a line with the lowest dorsal and the two or three upper lumbar vertebræ; the right kidney is a little lower than the left. Their shape is that of a bean, and their color a brownish red. They are made up of two very different substances, one covering the whole organ, called the *Cortical* substance; the other is called the *Medullary* substance, and consists of a series of pyramids, with their bases toward the surface of the organ, and their summits or renal papillæ toward the fissure. The substance of the kidney is mainly composed of secretory tubes, named *Uri'niferous tubules,* and blood-vessels with little connective tissues. These tubes are

lined with an epithelium, which secretes the urine. This secretion is conveyed to the bladder by a cylindrical tube called the *Ureter.* (Figs. 116, 117.)

347. The kidneys receive a very large supply of blood, and they are the only glands that eliminate certain nitrogenized substances from the blood.

Observation.—The retention of the secretion of the kidneys should never be allowed by the young or the old, the healthy or the diseased, as suppression of the secretion of these glands immediately affects the whole system, especially the nervous centres. Both the quantity and color of this secretion indicate the condition or health of the body.

FIG. 116.

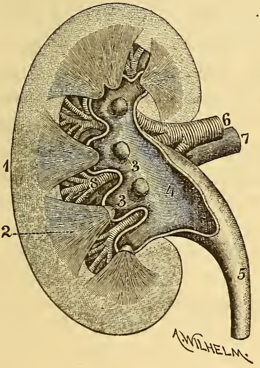

FIG. 117.

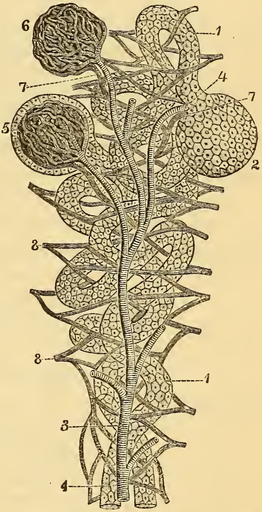

FIG. 116. LONGITUDINAL SECTION OF A KIDNEY.—1, Cortical substances. 2, Renal pyramid. 3, Renal papillæ. 4, Pelvis. 5, Ureter. 6, Renal artery. 7, Renal vein. 8, Branches of the latter vessels in the sinus of the kidney.

FIG. 117. DIAGRAM OF THE STRUCTURE OF THE KIDNEYS.—1, Two uriniferous tubules of the cortical substance lined with a pavement epithelium. 2, Dilatation of a tubule at its extremity. 3, Branches of the renal artery ending in vessels which enter the dilatations as seen at 4, 5. 6, Knot of blood-vessels freed from its investment. 7, Veins emerging from the vascular knots. 8, Plexus formed by the latter veins among the uriniferous tubules, from which plexus originate the branches of the renal vein.

ANALYTIC EXAMINATION.

CHAPTER IX.—ASSIMILATION.

§ 36. *Assimilation, General and Special.*—340. Distinguish between Primary and Secondary Assimilation; also General and Special Assimilation. 341. State the first stage in the nutrition of the organs and tissues. What is the second? The third? The fourth? The fifth? 342. How are new cell-elements produced? Where does this process occur after the body has attained maturity? 343. What is Special Assimilation? 344. Name the secreting glands and membranes. 345. How is excretion effected? Name the excretory organs. 346. What is said of Secretion and Excretion? In many secretory processes what happens? 347. Describe the kidneys. 348. What is their office? Observation.

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[Compare 340 with 3.]

In studying Assimilation, with what distinctions between organized and unorganized bodies do you become acquainted?

[Compare 341 and 342 with 11–14, 38, 39; 102, 103, 159, 164, 166, 167 and 412.]

Speak of the structure of cells, and tell how their growth is promoted.

[Compare 344 with 230–238 and 30–37.]

Name the secreting glands and membranes, and state the changes caused by their secretions.

[Compare 345–348 with 11, 12, 230–238, 343, 359–362, 486 and 487.]

Distinguish between excretion and secretion. Of what advantage is excretion?

SYNTHETIC TOPICAL REVIEW.

Assimilation, " Secondary, First Stage, " " Second " " " Third " " " Fourth " " " Fifth " Secretion, " its glands and membranes, Excretion, Secretion and Excretion, Kidneys.	§ 36. *Assimilation, General and Special.*	CHAP. IX. *Assimilation.*

State what you know of Assimilation, general and special, Secretion and Excretion.

CHAPTER X.

THE RESPIRATORY AND VOCAL ORGANS.

§ **37.** ANATOMY OF THE RESPIRATORY AND VOCAL ORGANS.—*The Organs of the Voice and of Respiration—The Larynx—Trachea—Bronchi—Lungs.*

348. THE RESPIRATORY AND VOCAL ORGANS consist of the *Larynx,* the *Trachea,* the *Bronchi* and the *Lungs,* the whole being acted upon by a complicated series of muscles.

349. The LARYNX, the organ of the voice, is a short, quadrangular, cartilaginous cavity, extending from the root of the tongue and the hyoid bone to the trachea, with which it becomes continuous below. It is separated from the spinal column by the pharynx, into which it opens above by a triangular and oblique aperture.

The Larynx is composed of five principal parts—the *Thy'-roid,* the *Cri'coid,* the two *Aryte'noid* cartilages and the *Epi-glot'tis.* The *Thyroid** is the largest cartilage. It consists of two lateral, quadrangular, winglike plates, which meet in front and form the prominence called *pomum Adami* (Adam's apple). This cartilage is connected with the hyoid bone above and with the cricoid cartilage below. (Figs. 118, 119.)

The *Cricoid*† cartilage is about one-fourth of an inch wide in front and one inch behind. This cartilage connects above with the thyroid cartilage by an articulation, permitting the latter to move downward and forward and also in the reverse direction; below, it communicates with the first ring of the trachea.

The *Arytenoid*‡ cartilages are two in number, small, trian-

* Gr., *thureos,* a shield. † Gr., *krikos,* a ring. ‡ Gr., *arutaina,* a pitcher.

gular and curved. They are placed upon the summit and back part of the cricoid cartilage, forming articulations.

The *Epiglottis* is oval-shaped, having its convex surface toward the mouth. It stands in a vertical position above the aperture of the larynx, which is closed by it in the act of swallowing. (Figs. 117, 118.)

350. The TRACHEA is a vertical tube about an inch in diameter and four inches in length. It is continuous with

FIG. 118.

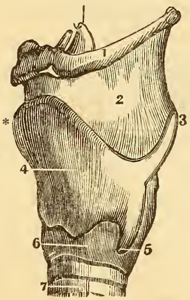

FIG. 119.

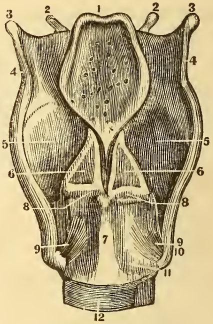

FIG. 118. A SIDE VIEW OF THE CARTILAGES OF THE LARYNX.—*, The front side of the thyroid cartilage. 1, The os hyoides (bone at the base of the tongue). 2, The ligament that connects the hyoid bone and thyroid cartilage. 3, 4, 5, The thyroid cartilage. 6, The cricoid cartilage. 7, The trachea.

FIG. 119. A BACK VIEW OF THE CARTILAGES AND LIGAMENTS OF THE LARYNX.—1, The posterior face of the epiglottis. 3, 3, The os hyoides. 4, 4, The lateral ligaments which connect the os hyoides and thyroid cartilage. 5, 5, The posterior face of the thyroid cartilage. 6, 6, The arytenoid cartilages. 7, The cricoid cartilage. 8, 8, The junction of the cricoid and the arytenoid cartilages. 12, The first ring of the trachea.

the larynx, and extends to the third dorsal vertebra, where it divides into two branches called *Bronchi.* The trachea is separated from the spinal column by the œsophagus. (Figs. 121, 122.)

351. The BRONCHI* carry air to their respective lungs and again divide, sending a branch to each lobe. These

* Gr., *brogchia,* the windpipe or throat.

divisions, called bronchiæ, are repeated until each ultimate ramification terminates in a dilatation called an *air-cell.* (Fig. 121.)

352. The LUNGS, consisting of two divisions, are situated in the cavity of the chest, enclosing between them the heart and the great blood-vessels. They accurately fill the cavity, adapting themselves to the varying size attending respiration. They have the form of a double but very irregular cone, with the apices above and the basal ends below. The outer surfaces are convex, fitting the form of the chest; the inner surfaces are concave, conforming to the shape of the heart; the basal portion is also concave, owing to the upward

FIG. 120.

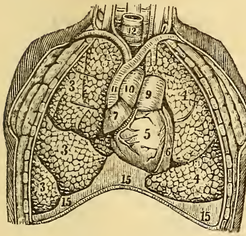

FIG. 121.

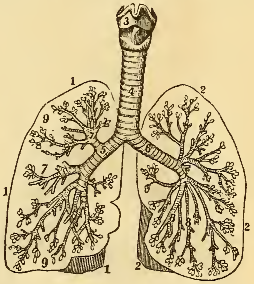

FIG. 120. THE LUNGS.—3, 3, 3, The lobes of the right lung. 4, 4, The lobes of the left lung. 5, 6, 7, The heart. 9, 10, 11, The large blood-vessels. 12, The trachea. 15, 15, 15, The diaphragm.

FIG. 121. THE BRONCHIÆ.—1, Outline of right lung. 2, Outline of left lung. 3, 4, Larynx and trachea. 5, 6, 7, 8, Bronchial tubes. 9, 9, Air-cells.

pressure of the diaphragm. They are everywhere unattached, excepting at the root, where they are firmly secured by the pulmonary ligaments, the pulmonary artery, the pulmonary veins and nerves and the bronchial tubes. The lungs are closely invested with a serous membrane, named *pleura.* The right lung is shorter than the left, but wider and of somewhat greater bulk. It is divided into three lobes, the middle lobe being the smallest, and the lowest one the largest. The left

lung has two lobes, of which the lower is the larger. (Figs. 120, 121.)

§ **38.** Histology of the Respiratory and Vocal Organs.—*Minute Structure of the Larynx—The Trachea—The Bronchi—The Lungs and Pleura.*

353. With the exception of the epiglottis, the so-called cartilages of the Larynx are true cartilage, and in advanced life are strongly disposed to ossify. They are invested with a fibrous membrane called *perichon'drium.** The articulations of the cricoid cartilage are lined with synovial membrane and covered with capsular ligaments. The epiglottis is of a soft, elastic nature, fibro-cartilaginous in structure and invested with mucous membrane. (Fig. 119.)

Fig. 122.

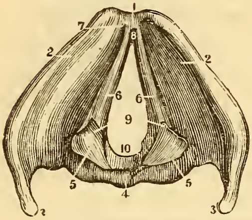

Fig. 123.

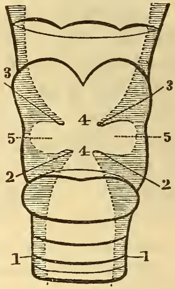

Fig. 122. A View of the Larynx, showing the Vocal Ligaments.—1, The anterior edge of the larynx. 4, The posterior face of the thyroid cartilage. 5, 5, The arytenoid cartilages. 6, 6, The vocal ligaments. 7, Their origin within the angle of the thyroid cartilage. 9, 10, The glottis.

Fig. 123. An Ideal Section of the Larynx.—1, The trachea. 2, 2, The lower vocal cords. 3, 3, The upper vocal cords. 4, 4, Rima glottidis, or glottis. 5, 5, Cavities between upper and lower vocal cords.

354. In the cavity of the larynx the mucous membrane is reflected at each side, outward and upward, forming a pair of pouches, called the ventricles of the larynx. Just below

* Gr., *peri*, around, and *chondros*, a cartilage.

these ventricles are the true *vocal cords*, extending from a small process on the fore part of each Arytenoid cartilage to the recessed part of the Thyroid cartilage. They are composed of yellow elastic tissue covered by mucous membrane, and form two ridges, having very fine, smooth edges turned toward each other and placed accurately on the same level. (Figs. 122, 123.)

355. The TRACHEA is made up of cartilage, fibrous tissue, muscle and mucous membrane. The cartilaginous part consists of flattened rings or rather segments of circles, as they are wanting in that part of the tube next to the spine. The last ring is so modified as to accommodate it to the two first rings of the bronchi. The fibrous part is of yellow elastic tissue. It commences at the cricoid cartilage, and not only covers the rings in front, but forms for each a distinct sheath, thicker in front, and gradually losing itself with the termination of the rings. The posterior third of the trachea has a basis of strong, elastic fibrous tissue, arranged in longitudinal bands. The muscular portion has a simple layer of fibres running transversely, being attached to the ends of the cartilaginous rings and to the connecting tissue. The trachea is lined with mucous membrane. (Fig. 121.)

356. The BRONCHI are constructed like the trachea, excepting in the ultimate bronchial ramifications, where the cartilages are composed of several pieces distributed around the tube, and the muscular fibres form a continuous layer. The cartilaginous element finally disappears, when the tubes consist only of fibro-elastic membrane with muscular fibres and a lining mucous membrane. (Fig. 121.)

357. The LUNGS are made up of numerous small, polyhedral, primary lobules or clusters of air-cells, which unite into larger secondary lobules. The lobules seem to have no communication with each other, each primary lobule being in itself a miniature lung, performing independent functions. It has been calculated that no less than eighteen thousand of these air-cells group around each terminal tube, giving a sum-total of not less than six hundred millions. (Figs. 120, 124.)

The air-cells are connected together by fibro-elastic tissue, which renders them highly elastic. The cells are surrounded by fine networks of capillary vessels, the terminations of the branches of the pulmonary artery which accompany the branches of the bronchi. The trachea, bronchial tubes and air-cells are lined with a mucous membrane having a *ciliated epithelium*.

Fig. 124.

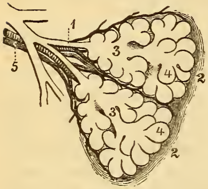

Fig. 124. Diagram of Two Primary Lobules of the Lungs, magnified.—1, Bronchial tube. 2, A pair of primary lobules connected by fibro-elastic tissue. 3, 3, 3, Inter-cellular air-passages. 4, 4, 4, Air-cells. 5, Branches of the pulmonary artery and vein.

Observation.—The independent cluster of air-cells or lobules which compose the lungs may, one or more, become diseased, or their epithelium may be affected and the other portion of the lung be healthy.

358. The Pleura is a serous membrane which lines the thorax, and then is reflected from the root of each lung over its surface. A fold of this membrane extends from the root downward to the diaphragm, and is called the pulmonary ligament. The pleural cavity is lubricated by the serous secretion, thus preventing friction during the respiratory movements. By the approximation of the two pleuræ in the median line, they form the *medias'tinum*, or partition of the thorax, which contains the heart enclosed within its pericardium. (Figs. 16, 120.)

§ 39. Chemistry of the Respiratory and Vocal Organs.

359. Respiration consists of two conjoint processes—that of supplying to the body the requisite amount of vitalizing oxygen by inspiration, and that of removing from the body the deleterious carbonic acid by expiration. The source of the oxygen is the air; the sources of carbonic acid are the blood and the tissues. Some carbonic acid is generated in the blood, both from the respiratory or heat-giving elements of food, which chiefly enter the blood and are there oxidized, and from the changes of growth and decay to which the corpuscles of the blood are themselves subject. It is also

probable that some intermediate or partly oxidized products of the decomposition of solid tissues undergo further oxidation in the blood.

360. We find the main source of carbonic acid, however, in the tissues. It appears both as a product of their natural decay, and of muscular and nervous activity. The sum of all the *chemical changes* of the body is *oxidation*, and the chief product of this oxidation is carbonic acid.

361. The proportions of oxygen and carbonic acid in venous and arterial blood are—

	Oxygen.	Carbonic Acid.
100 vols. venous blood	5 vols.	25 vols.
100 vols. arterial blood	10 vols.	20 vols.

It has also been found that the proportions of oxygen and carbonic acid in venous blood returning from muscles *at rest* are—oxygen, 7.5 vols., carbonic acid, 31; from muscles *in action:* oxygen, 1.265 vols., carbonic acid, 34.4.

362. The exchange of oxygen and carbonic acid in the capillaries is effected partly by physical and partly by chemical processes. The physical process is in accordance with the law of the "diffusion of gases." Two gases of different densities, and having no chemical affinity for each other, will intermix when brought into contact, and also when separated by a porous septum, provided they have no chemical affinity for that septum. These are the exact conditions in the capillaries; the oxygen and carbonic acid are the two gases, the capillary walls, the porous septum. In addition to this physical process there is a chemical process; the venous blood has a strong affinity for oxygen, hence readily unites with it in the pulmonic capillaries. When the arterial blood reaches the systemic capillaries, it yields its oxygen to the elements of the decomposing tissues which surround them. The carbon and hydrogen in their *nascent* state, or at the *moment of liberation*, seize the oxygen with great avidity, and give in exchange carbonic acid and water.

363. The air of expiration differs from that of inspiration not only in its increase of carbonic acid, but in that of moisture

and of temperature. As a rule, the expired air is saturated with moisture. The drier the external air, the greater the pulmonary exhalation, for in breathing air already saturated only so much more can be added as the higher temperature of the body will enable it to dissolve. The pulmonary exhalation has, besides water and carbonic acid, traces of ammonia, chlorides, urates, and even some albuminous substances; it readily undergoes decomposition.

364. The heat of the body, often called *animal heat*, is the result of the various chemical actions. The temperature of the tissues generally ranges from 98° to 100°; that of blood from 100° to 102°. The blood varies in temperature in different parts, being warmest in the hepatic veins.

§ **40.** PHYSIOLOGY OF THE RESPIRATORY AND VOCAL ORGANS.—*Objects of Respiration. Two Modes of Respiration. Renovation of the Air in the Lungs. Amount of Air in each Respiration. Conditions affecting the Number of Respirations. Modifications of Respiratory Movements. Double Function of the Larynx. Resemblance between the Action of the Vocal Cords and Reed Instruments. Conditions affecting the Tone and Strength of the Voice.*

365. The FUNCTION OF RESPIRATION has for its immediate object the *purification of the blood*, and for its ultimate uses the *production of heat, motion and nervous energy.* The blood which becomes impure in the systemic capillaries is carried to the pulmonary capillaries, which everywhere surround the air-cells. Through the thin walls the poisonous carbonic acid passes from the capillaries into the air-cells, and is expelled from the body; at the same time the oxygen of the external air passes from the air-cells into the capillaries, and the blood is changed from a dark maroon to a bright red color.

The chemical changes in every part of the body caused by the union of this oxygen with carbon, hydrogen and other elements of the blood and tissues, maintain the temperature of the body and are the source of its nervous power and electricity.

366. Respiration consists of two acts, taking air into the

lungs or *inspiration*, and expelling air from the lungs or *expiration.* An act of *Inspiration* is effected by the enlargement of the chest, which is done by elevating the ribs and sternum and depressing the convex surface of the diaphragm. To elevate the ribs two sets of muscles are used. Those which

FIG. 125.

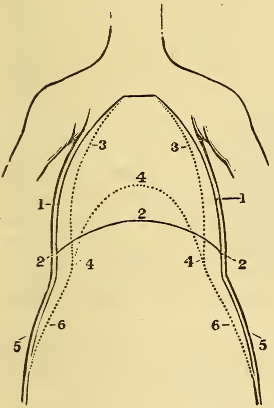

FIG. 126.

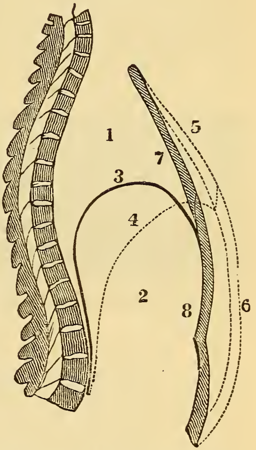

FIG. 125. A FRONT VIEW OF THE CHEST AND ABDOMEN IN RESPIRATION.—1, 1, The position of the walls of the chest in inspiration. 2, 2, 2, The position of the diaphragm in inspiration. 3, 3, The position of the walls of the chest in expiration. 4, 4, 4. The position of the diaphragm in expiration. 5, 5, The position of the walls of the abdomen in inspiration. 6, 6, The position of the abdominal walls in expiration.

FIG. 126. A SIDE VIEW OF THE CHEST AND ABDOMEN IN RESPIRATION.—1, The cavity of the chest. 2, The cavity of the abdomen. 3, The line of direction for the diaphragm when relaxed in expiration. 4, The line of direction for the diaphragm when contracted in inspiration. 5, 6, The position of the front walls of the chest and abdomen in inspiration. 7, 8, The position of the front walls of the abdomen and chest in expiration.

are attached to the upper rib and sternum contract and elevate the anterior extremities of the ribs; this enlarges the cavity between the spinal column and the sternum. The central portion of the ribs is raised by the intercostal muscles. The second rib is elevated by the contraction of the

muscles between it and the first; the third rib is raised by the combined action of the muscles between the first and second and between the second and third. The motion of each succeeding rib is increased in the same way, so that the movement of the twelfth rib is very free, as it is elevated by the contraction of eleven sets of intercostal muscles. Simultaneously with the elevation of the ribs the central portion of the diaphragm is depressed by the contraction of its muscular margin and the relaxation of the muscular walls of the abdomen. By these combined movements the chest is enlarged in every direction. This enlargement of the thorax tends to produce a vacuum between the thoracic walls and the lungs; hence, the pressure of the external air fills the air-cells, forcing the elastic lungs to expand and fill the cavity. The elastic walls of the air-cells yield in every direction; so also do the surrounding areolar tissue and the pleura. The air-tubes yield both in a circular and a longitudinal direction. In difficult respiration almost every muscle in the body is made in some way subservient to the distension of the chest. (Figs. 125, 126.)

367. In *Expiration* the movements are of a more passive character, depending mainly on the relaxation of the inspiratory muscles and the elastic *resilience** of the tissues concerned. When the muscles relax, the sternum and ribs descend, the diaphragm vaults upward, the elastic walls of the air-cells diminish their size, the longitudinal and circular fibres of the bronchi and bronchiæ shorten and narrow their tubes, and the entire elastic lungs rebound like an extended spring let loose, while the interlobular and sub-pleural tissues aid powerfully in compressing them on all sides.

368. When respiration is performed chiefly by the diaphragm, it is called *abdominal* respiration; when chiefly by the action of the ribs, *pectoral* respiration. The former is the characteristic mode in men and children; the latter, in women.

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* Lat., *re*, back, and *salio*, to spring.

369. The ordinary respiratory movements alone would not renovate the air in the smaller air-tubes and air-cells. Additional aid is rendered in two ways: 1st, By the *diffusion of gases*, causing the carbonic acid and the oxygen to mix equally in all parts of the lungs; and 2d, By the *epithelial air-current*. In the lining mucous membrane of the trachea and the bronchial tubes, the cilia of the epithelium are always directed from below upward, and, like all ciliary motion, it has the effect of producing a current in the fluids of the mucous membrane. Now, the air in the tubes must move to a certain extent with this current; hence a double stream of air is established in each bronchial tube, one current passing from within outward, along the walls of the tube, the other passing from without inward, along the central part. Thus a kind of aerial circulation is maintained, which, together with the mutual diffusion of the gases and the ordinary respiratory movements, ensures a complete renovation of the air in all portions of the pulmonary cavity. (Fig. 127.)

Fig. 127.

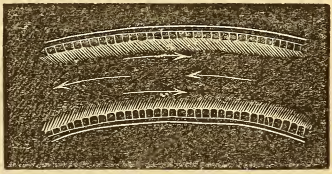


Fig. 127. Diagram of a Small Bronchial Tube, showing outward and inward current, produced by ciliary motion.

370. The amount of air taken in and given out in a respiratory movement must vary with different individuals and different conditions of the system. The volume of air ordinarily received by the lungs in a single inspiration is about one pint; the volume expelled, a little less than a pint. In the mutual action that takes place between the air and the blood every twenty-four hours, the air loses about thirty-seven ounces of oxygen, and the body fourteen ounces of carbon.

Observation 1.—Respiration is more frequent in women and children than in men. Persons of small stature breathe more frequently but less deeply than taller people. In health, the smallest number of

respirations in a minute by an adult is not less than fourteen, and they rarely exceed twenty-five; eighteen may be considered the average number. The number of respirations is increased by exercise, food, stimulants and moderate cold, while it is diminished by inactivity, moderate heat, starvation and general weakening influences, especially mental depression.

2.—The actions of *sighing, yawning, sobbing, laughing, coughing* and *sneezing* are simple modifications of the ordinary movements of respiration, excited either by mental emotions or by a stimulus arising in the respiratory organs themselves. Sighing and yawning often occur as simple results of deficient aeration; sometimes the former results from depression of the feelings; the latter from mere imitation. Laughter and weeping seem to be always either expressions of the emotions or simple results of sensations. Coughing and sneezing are occasioned by irritation in the air-passages, and the sudden expiratory movement has a tendency to remove all intruding substances.

371. The LARYNX performs a double function, one part being concerned with respiration, the other with the voice.

In inspiration the vocal cords separate, allowing the air to pass in freely; in expiration they relax. The former movement is active; the latter, passive. Both co-operate with the other respiratory movements. Vocal sounds are further modified by the elevation and depression of the larynx, for when the voice is raised from a low to a high pitch the whole larynx is elevated toward the base of the skull, drawing with it the trachea; the vocal tube is thus slightly lengthened, the diameter of the trachea lessened, and variations are produced in the tension of its walls, enabling it to accommodate itself to the different vocal tones. The larynx, however, is the special organ of the voice, sounds being produced by the vibratory action of the vocal cords. During ordinary, tranquil breathing, the cords are widely separated, the glottis being of triangular shape; but when a vocal sound is to be produced, the arytenoid cartilages are said to become erect and almost to touch each other, the cords are made suddenly tense, closing the posterior portion of the glottis, while the anterior two-thirds opens a very fine fissure, and the air, driven by an unusually forcible expiration through the narrow opening in passing between the

vibrating vocal cords, is itself thrown into vibrations which produce the sound required.

Observation 1.—The extreme sensibility of the vocal cords and the posterior part of the epiglottis causes them to throw off any foreign substances happening to come in contact with them, by a sudden, expulsive cough.

2.—The vibrations of the vocal cords take place according to the laws which regulate the action of the stretched membranous tongues or reeds in reed instruments. If one extremity of a short tube be covered by two portions of elastic membrane, leaving a small chink between them, a form of double membranous tongue is obtained, which resembles the vocal cords in man. The narrower the chink, the more easily are the sounds produced. The size, however, in no way affects the *pitch*, which is somewhat determined by the length, tension and thickness of the tongues, but chiefly by the *tension*.

3.—The *tones* of different individuals are doubtless modified by the shape and size of the vocal apparatus. Thus, a large larynx usually gives a deep-toned voice; a smaller one gives a comparatively high pitch. The difference in the tone of the *male* and female voice is due largely to the great difference in the walls of the larynx. In the female the cavity is smaller, the angle in front less acute, and the cartilage softer.

4.—The general *strength* of the voice depends upon the capacity of the chest, the development of the muscles used in vocalization, the extent to which the vocal cords can vibrate, and the power of communicating resonance possessed by the air-passages and neighboring cavities.

§ **41.** HYGIENE OF THE RESPIRATORY AND VOCAL ORGANS.—*Importance of Proper Respiration. Effect of Carbonic Acid Gas upon Respiration and Combustion. Sources of this Gas. Location of Dwellings. Danger of Impure Air within the House. Importance of Ventilation in Public Buildings—In Sleeping-rooms—In Sick-rooms. Means of securing Warm and Pure Air in Winter. Importance of Moisture in the Air. Effect of Compressing the Respiratory Organs. Means of Enlarging the Chest. Influence of the Nervous System upon Respiration.*

372. In the circulating system we have seen the minutest care manifested in supplying each organ, tissue and cell with blood. If the blood be pure, this is the best conceivable arrangement for securing health and vitality; if impure, the

means is equally effective for poisoning every part of the system.

373. Pure blood can be obtained only by a healthy action of the respiratory organs, and this action only by a constant and sufficient supply of pure air. Limit this supply, and the stimulus furnished to the nervous and muscular tissues is withdrawn, and the carbonic acid is retained in the blood. Hence, the brain works sluggishly, the muscles become inactive, the heart acts imperfectly, the secretions are deteriorated, the food is not properly assimilated, and the whole body becomes *weak*.

374. Pure air is composed of oxygen and nitrogen in about the proportion of 21 to 79. The air is most frequently rendered unfit for vital purposes by the presence of carbonic acid gas and volatile particles of corrupted animal matter.

Observation 1.—The sources of this deleterious gas are mainly decaying animal and vegetable matter, combustion and the respiration of animals. Plants in their healthy state take up carbonic acid gas and give out oxygen, thus maintaining, under ordinary circumstances, a pure and respirable atmosphere. Carbonic acid gas will not support combustion, as may be seen by introducing into it a burning taper, which is as readily extinguished as if dipped in water. Neither will it support life; if a small animal be placed in a jar of the gas, life soon becomes extinct.

2.—In wells, mines and caves, where the circulation is obstructed, this gas often accumulates in quantities sufficient to cause death to those who enter. Hence, before entering them, the air should be tested by a lighted taper. If it will not burn, respiration cannot be maintained.

375. *The location of dwelling-houses should be chosen with reference to free circulation of air and the avoidance of marshes, stagnant pools, slaughter-houses and other sources of vegetable and animal decay.* Careful attention should also be given to the drainage of a house, and to the *cellar*. These underground store-rooms should always be well ventilated, and all vegetables removed from them in early spring. A little neglect in these and like respects has not unfrequently prostrated a whole family with typhoid disease.

Observation.—The chief danger, however, is *within* the house proper,

and from the breaths of its inmates. Unless ventilation receives proper attention, the carbonic acid gas from the lungs and the effete particles of animal matter thrown off from the system will soon render the air poisonous.

376. *School-rooms, churches, concert-halls, and all rooms designed for public purposes should be amply ventilated.* The child at school becomes listless and uninterested; why? *Because he is stupefied by foul air.* When a pupil continues to breathe such air month after month, his brain is injured, and often consumption or other fatal disease destroys his young life, and then we wonder at the "mysterious providence" that takes from us the gifted and beautiful.

Observation 1.—The good man at church feels that he *ought* to be interested in the services, and yet, powerless to fix his attention, he sits nodding; why? *Because he is stupefied by foul air.* The air breathed over and over again last Sabbath and shut in during the week is all the poor man can obtain.

2.—The lamps of the concert-hall burn dimly long before the closing hour; why? *Because they are bedimmed by the foul air;* and just in proportion to the decrease of light is the increase of dullness in the audience.

377. *The sleeping-room should be thoroughly ventilated.* Proper ventilation would often prevent morning headaches, want of appetite and general languor so common among the feeble. The impure air of sleeping-rooms probably causes more deaths than intemperance. Those who live in open houses little superior to the sheds that shelter the farmer's flocks are usually the most healthy and robust; headaches, liver complaints, coughs and a multitude of nervous affections are almost unknown to them. Not so with those who spend their days and nights in rooms with double or caulked windows, breathing over and over again the confined air; disease and suffering are their constant companions.

Observation 1.—By many a sleeping apartment twelve feet square and seven feet high is considered spacious for two persons and "good accommodation" for four. This room contains one thousand and eight cubic feet of air. Allowing ten cubic feet to each person per minute, two occupants would vitiate the air in fifty minutes and four in twenty-five minutes.

2.—Among children convulsions or fits often occur when they are sleeping, and not unfrequently in consequence of impure air. In such cases, by carrying the sufferer into the open air relief is afforded. Children should not sleep in *low beds* while adult persons occupy a higher bed in the same unventilated room, as carbonic acid is most abundant near the floor; nor is it advisable that the young sleep with the sick or aged.

378. *The ventilation of the sick-room should receive special attention.* It is no unusual practice when the patient is suffering from acute disease for the attendants to prevent the ingress of pure air, simply from the apprehension that the sick person will take cold; and caution is indeed necessary: the patient should not *feel the current.* No room is suitable for sickness that is not so arranged that pure air may be constantly admitted without inconvenience or injury to the patient; and here we would say that *cool* air should not be mistaken for *pure* air. A very little sound judgment in this matter would doubtless save much suffering and lengthen life in a multitude of cases. The custom of having several persons sit in the sick-room vitiates the air and delays the recovery of the patient.

379. *The great means of ventilation in summer are open windows and doors. Motion* is at that season the great desideratum. On a hot summer's day we go into a cool room that has been shut up, and at first it is grateful, but in a short time the cool, stagnant air becomes oppressive, and we select the open window with its *circulation* of air, even if it is a little warmer. Windows should be made to lower from the top.

380. *In winter, ventilation may be obtained by properly-constructed flues.* As cold weather approaches we must close the windows, excepting when in bed, but good flues secure a good circulation of air.

Observation 1.—For heating a small room, where the occupants may change position at pleasure, an open fire is the healthiest known means, for the air cannot become stagnant, as the fire is continually drawing a considerable amount from the room to support combustion, the place of which is supplied by other air. Just here comes in the greatest in-

convenience of the open fire: if the cold air comes in at the cracks of a door or window on the opposite side of the room, it will flow across to the fire, chilling the feet and backs of those sitting in its track.

2.—A stove is a very economical mode of heating ordinary sitting-rooms, offices, etc.; but there should be an air-chamber or box on or near the top of the stove, and communicating with this should be a pipe for introducing fresh air from the external atmosphere. If this supply of fresh air is abundant, with a constant evaporation of moisture, and an opening into a heated flue near the ceiling, to be opened when the room is overheated or the lights are burning in the evening and kept closed at other times, with another opening into a heated flue on a level with the floor, which should be *always open*, to carry off the cold, heavy, foul air from the floor,—if a stove be thus arranged for many small, isolated rooms, it is one of the most economical, comfortable and wholesome means of heating at our command.

3.—"Probably one of the very best arrangements is to have a good steam furnace, with a large fresh-air box, letting in an abundance of air moderately warmed and overflowing the house with this, also to have some direct radiation in the halls, and a bright, cheerful, open fire in the family sitting-room." Two things are indispensable in every furnace—a large fresh-air box communicating with the *external atmosphere*, and a large *evaporating* vessel. Few persons realize the necessity of supplying a proper amount of moisture in our stove and furnace-heated rooms. If it is not furnished by other means, the heated air will have it from the natural moisture of the skin and lungs, thus producing a dry, parched, feverish condition of the system.

381. *The conditions of proper respiration require not only that the air be pure, but sufficient in quantity; hence the chest and lungs must not be reduced in size.* In children who have never worn close garments, the circumference of the chest is generally about equal to that of the body at the hips; and similar proportions would exist through life if there were no improper pressure of the clothing. Such is the case with the Indian woman, whose blanket allows the free expansion of the chest. The symmetrical statues of ancient sculpture bear little resemblance to the "beau ideal" of American notions of elegant form.

Observation.—The Chinese, by compressing the feet of female children, prevent their growth, so that the foot of a *Chinese belle* is not larger than the foot of an American girl of five years; the American

women *compress their chests*, so that the chest of an *American belle* is not larger than the chest of a Chinese girl of five years. In these respects, which country exhibits the greater intelligence?

382. *Individuals may have small chests from birth*, this being, to the particular individual, natural. That like produces like is a general law. If the mother has a small, tapering waist, either hereditary or acquired, the form may be impressed on her offspring, thus illustrating the truthfulness of Scripture, which declares that the sins of the parent shall

FIG. 128. FIG. 129.

FIG. 128. A CORRECT OUTLINE OF THE VENUS DE MEDICI, the *beau ideal* of female symmetry.

FIG. 129. AN OUTLINE OF A WELL-CORSETED MODERN BEAUTY.

One has an artificial, insect waist; the other, a natural waist. One has sloping shoulders, while the shoulders of the other are comparatively elevated, square and angular. The proportion of the corseted female below the waist is also a departure from the symmetry of nature.

be visited upon the children unto the third and fourth generations. (Figs. 37, 129.)

Observation 1.—The question is often asked, Can the size of the chest and the volume of the lungs be increased when they have been once compressed? Yes. The means to be used are, a full inflation of the lungs at each act of respiration, and a judicious exercise of them by

walking in the open air, reading aloud, singing, sitting erect and practicing appropriate gymnastic exercises. Unless these exercises are systematic and persistent, they will not afford the beneficial results desired.

2.—Persons of sedentary habits should often, during the day, take full, deep breaths, filling the smallest air-cells with air; the shoulders should be thrown back and the head held erect.

383. *Respiration is much influenced by the condition of the nervous system.* Abstract thought, anxiety and the depressing passions diminish the contractile energy of the diaphragm and the muscles that elevate the ribs, thus preventing the full inflation of the lungs. Cheerfulness, joy and all the exhilarating emotions favor free respiration, and consequently promote health.

§ **42.** COMPARATIVE PNEUMONOLOGY.—*Respiratory Apparatus of Mammals—Of Birds—Of Reptiles—Of Amphibians—Of Fishes.*

384. The RESPIRATORY APPARATUS in other *Mammals* is similar to that of man both in structure and function. There are similar arrangements and movements of the ribs, sternum, intercostal muscles and diaphragm. The lungs fill the cavity of the thorax, and have the same general composition of lobes, lobules and air-cells.

385. In *Birds* the lungs are confined to the back wall of the chest. They are not separated into lobes, but are oblong and flattened in shape, and connected with a series of air-receptacles scattered through various parts of the body. In birds the larynx, trachea, bronchia, pulmonary arteries, veins and capillaries are much modified. The ultimate pulmonary capillaries do not form a network lining definitely-bounded air-cells, as in mammals, but each vessel crosses an open air-space of its own. They interlace in every direction, forming a mass of capillaries permeated everywhere by air. (B, fig. 132.) This arrangement not only reduces the specific gravity of the body, but also assists largely in the aeration of the blood. A marked modification of the respiration of birds of flight is the connection of the pores of the bones and feathers with the bronchial tubes and air-spaces of the lungs, so that

there is an interchange of air between the lungs, the bones and the investing plumage. Birds consume more air in a given time, proportionally, than any other vertebrate, and they soonest die when deprived of it.

Fig. 130.

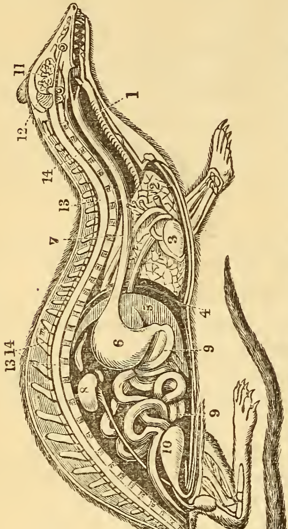


Fig. 130. Section of a Small Mammal.—1, Trachea. 2, Lungs. 3, Heart. 4, Diaphragm. 5, Liver. 6, Stomach. 7, Œsophagus. 8, Kidney. 9, 9, Intestines. 10, Bladder. 11, Cerebrum. 12, Cerebellum. 13, 13, Medulla spinalis. 14, 14, Vertebræ.

386. In *Reptiles* respiration is more simple than in mammals or birds. The lungs are less lobular and more bag-like, extending into the abdominal cavity. Upon the walls of these sac-like lungs the pulmonary vessels ramify. Owing to a less energetic respiration, the movements of Reptiles are not so well sustained.

387. The Amphibians when young (tadpoles) breathe by gills; before becoming adult they acquire lungs, but the respiration is comparatively inactive. In Frogs the thorax is not so formed as to act like a suction-pump, and accordingly these animals swallow the air by a sort of deglutition.

388. In *Fishes* respiration is performed by means of the air dissolved in the water. Instead of lobular or bag-like lungs, there are found only a series of slit-like openings or arches on each side near the head, called the branchiæ or gills. The bony and cartilaginous frames of these arches on the convex

FIG. 131.

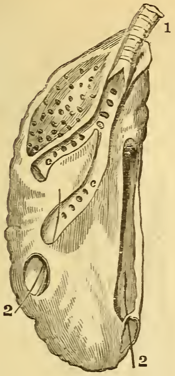


FIG. 132.

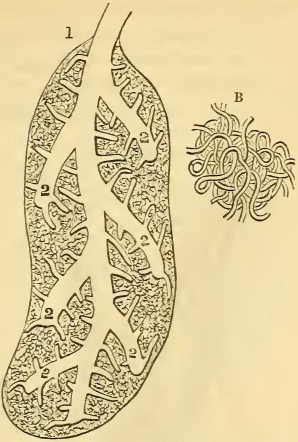


FIG. 131 (*Owen*). THE RIGHT LUNG OF A GOOSE.—1, A bronchus which divides into two tubes that open into the abdominal air-receptacles at 2, 2.

FIG. 132 (*Owen*). IDEAL SECTION OF A BIRD, MAGNIFIED TWO HUNDRED AND SIXTY TIMES.—1, A primary bronchus dividing into secondary bronchi that end in cæca, 2, 2, 2, 2, 2, 2. Those secondary bronchi give off smaller penniform branches that ramify among the lobules. B, A plexus of capillary vessels.

FIG. 133.

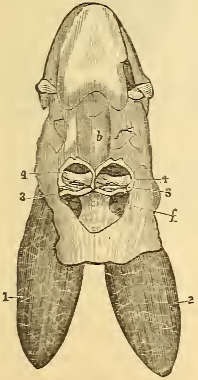


FIG. 134.

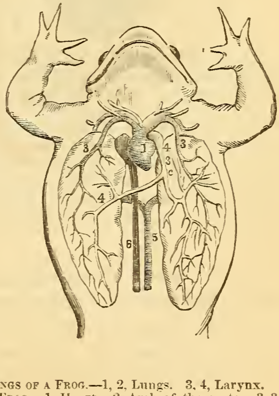


FIG. 133 (*Owen*). TONGUE, LARYNX AND LUNGS OF A FROG.—1, 2, Lungs. 3, 4, Larynx.

FIG. 134 (*Owen*). HEART AND LUNGS OF A FROG.—1, Heart. 2. Arch of the aorta. 3, 3, Pulmonary artery. 4, 4, Pulmonary veins. 5, 5, Aorta. 6, Vena cava.

side support processes. On these are many plates or leaflets, covered by a delicate tessellated membrane or epithelium, on which the microscopic capillary blood-vessels ramify. By this arrangement of extensive epithelial surface, the blood-particles are more minutely separated and acted upon by the

Fig. 135.

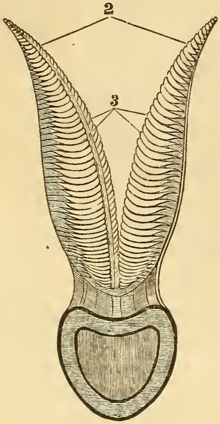


Fig. 136.

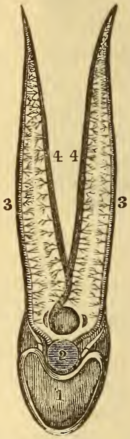


Fig. 135 (*Owen*). Section of a Branchial Arch, with a pair of processes supporting leaflets or plates from a cod, magnified two hundred and sixty diameters.—1, A section of a branchial arch. 2, A pair of processes. 3, Branchial leaflets or plates. The number of leaflets in one process of the cod is about one thousand; in the salmon, fourteen hundred; in the sturgeon, sixteen hundred.

Fig. 136 (*Owen*). A Circulation of the Blood through the Branchial Leaflets (a diagram).—1, A section of a branchial arch. 2, A section of a branchial artery. 3, An artery sent along the outer margin of the processes, giving off capillary vessels to the leaflets. 4, A vein that receives the blood from the capillaries on the inner margin of the process after the respiratory change has been effected and returns it to the branchial vein (5).

air in the water. In breathing, the mouth and gills of a fish open alternately; the water entering the mouth escapes by the openings of the gills. (Figs. 135, 136.) A remarkable feature in the organization of some fish is the swimming or air-bladder, placed in the abdomen under the dorsal spine, commu-

nicating often with the œsophagus or stomach by a canal, permitting the escape of air from its interior. By a movement of the ribs the air-receptacle is acted on, so that by diminishing the quantity of air the specific gravity of the fish alters according to circumstances. Fish that swim near the bottom have no air-bladder, as the Eel and Turbot. (Fig. 82.)

FIG. 137.

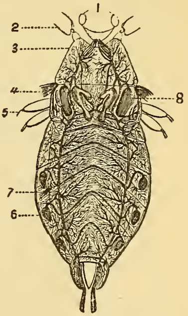


FIG. 137. THE RESPIRATORY ORGANS OF THE NEPA (Water Scorpion).—1, The head. 2, Base of the feet of the first pair. 3, First ring of the thorax. 4, Base of wings. 5, Base of the feet of the second pair. 6, Stigmata. 7, Tracheæ. 8, Aerial vesicles.

389. In some species of the *Annulosa,* as certain Spiders, the respiration is effected by air-bearing tubes (tracheæ), which communicate with the exterior by small apertures called *Stig'mata.* These openings often have valves which open and shut like the folding of a door. Through the air-bearing tubes the function of respiration is performed in every part of the body. This mode of breathing is peculiar to insects.

390. In the *Mollusca* the respiratory organs vary. Some have the form of lungs, but in a state of great simplicity, like the Land-snail, while a large class have leaf-like gills, constituting what is known in the Oyster as the "beard."

ANALYTIC EXAMINATION.

Chapter X.—The Respiratory and Vocal Organs.

§ **37.** *Anatomy of the Respiratory and Vocal Organs.*—348. Of what do the Respiratory and Vocal organs cousist? 349. Describe the Larynx. Of what is it composed? What is said of the Thyroid cartilage? Of the Cricoid? Of the Arytenoid? Of the Epiglottis? 350. What is the Trachea? 351. Give the divisions aud subdivisions of the Brouchi. 352. Of how many divisions do the Lungs consist, and where situated? Of what form are they? What is the Pleura? Compare the Lungs.

§ **38.** *Histology of the Respiratory and Vocal Organs.*—353. What is said of the structure of the Larynx? Describe the Vocal cords. 354. Of what is the Trachea made up? Speak of each part. 355. Distinguish between the Bronchi and Trachea. 356. How are the Lungs constructed? In what way are the air-cells connected together? Observation. 357. Describe the Pleura.

§ **39.** *Chemistry of the Respiratory and Vocal Organs.*—358. Of what does Respiration consist? 359. State the sources of carbonic acid. 360. Give the proportions of oxygen and carbonic acid in the arterial and venous blood. 361. State the physical process by which an exchange of oxygen and carbonic acid in the capillaries is effected; also the chemical process. 362. In what respect does expired air differ from that inspired? 363. What is the source of animal heat? Of what temperature the tissues and blood?

§ **40.** *Physiology of the Respiratory and Vocal Organs.*—364. What are the objects of Respiration? What are the results of the chemical changes? 365. Of what acts does respiration consist? How is inspiration effected? 366. What is said of the movements in expiration? 367. Define abdominal and pectoral respiration. 368. How is the air in the air-cells renovated? 369. Compare air inspired with that expired. Observations. 370. What is the office of the Larynx in respiration? Of what is the Larynx the special organ? Observations.

§ **41.** *Hygiene of the Respiratory and Vocal Organs.*—371. In the Circulatory system, what have we seen manifested? 372. Why must there be a constant and sufficient supply of pure air? 373. What is the composition of air? Observations. 374. What regard should be had for the surroundings of our dwelling-houses? Observation. 375. What remarks as to the necessity of ventilation of school-rooms, churches and concert-halls? Observations. 376. What is said of the ventilation of sleeping-rooms? Observations. 377. What attention should be paid to the sick-room? 378. Speak of the means of ventilation in summer. 379. What means in winter? Observations. 380. What besides purity of air is required for proper respiration? Observation. 381. What effect has compression of the mother's chest on her offspring? Observations. 382. By what is respiration much influenced?

§ **42.** *Comparative Pneumonology.*—383. How does the Respiratory apparatus in other mammals compare with that in man? 384. Describe the Lungs of Birds. What is said of the Ultimate Pulmonary Capillaries? What marked modification of respiration in birds of flight? 385. Speak of respiration in Reptiles. 386. In Amphibians. 387. In Fishes. What remarkable feature in the organization of some fish? 388. Speak of respiration in some species of the Annulosa. 389. In Mollusca.

UNIFIC REVIEW.

[Compare 349–357 with 384–390.]

Compare each respiratory organ in man with that in the lower classes of animals.

[Compare 354–356 with 17–19 and 21.]

Name the tissues found in the organs of respiration. How disposed?

[Compare 357 with 19, 30, 31 and 318.]

What tissue in the lungs? Describe the variety of epithelium found in the organs of respiration, and name those organs.

[Compare 358 with 33.]

What membrane forms the pleura? What is said of it and its secretion?

[Compare 359–363 with 38, 39, 43 and 63–65.]

Give the chemical changes which occur during respiration.

[Compare 364 and 365 with 168, 171 and 172.]

What chemical actions produce heat? State the influence of respiration on motion.

[Compare 381 and 382 with 189.]

Of what advantage is exercise of the lungs? What is necessary after exercise?

[Compare 383 with 194, 196, 439, 445, 448 and 449.]

What relation is there between respiration and mental energy? What caution is given?

FIG. 138.

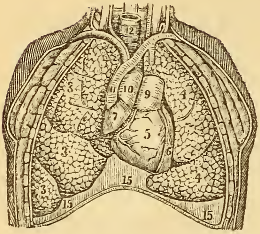


FIG. 139.

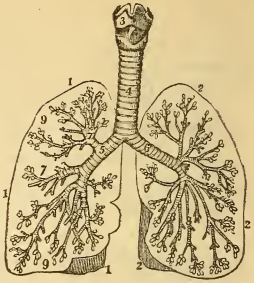


FIG. 138. THE LUNGS.—3, 3, 3, The lobes of the right lung. 4, 4, The lobes of the left lung. 5, 6, 7, The heart. 9, 10, 11, The large blood-vessels. 12, The trachea. 15, 15, 15, The diaphragm.

FIG. 139. THE BRONCHIÆ.—1, Outline of right lung. 2, Outline of left lung. 3, 4, Larynx and trachea. 5, 6, 7, 8, Bronchial tubes. 9, 9, Air-cells.

FIG. 140.

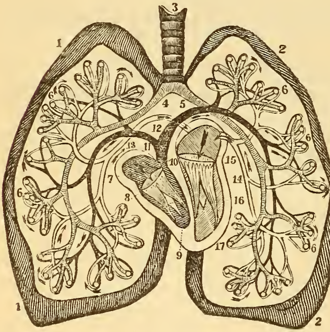


FIG. 141.

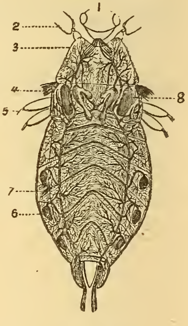


FIG. 140. AN IDEAL VIEW OF THE PULMONIC CIRCULATION.—1, 1, The right lung. 2, 2, The left lung. 3, The trachea. 4, The right bronchial tube. 5, The left bronchial tube. 6, 6, 6, 6, Air-cells. 7, The right auricle. 8, The right ventricle. 9, The tricuspid valves. 10, The pulmonic artery. 11, The branch to the right lung. 12, The branch to the left lung. 13, The right pulmonic vein. 14, The left pulmonic vein. 15, The left auricle. 16, The left ventricle. 17, The mitral valves.

FIG. 141. THE RESPIRATORY ORGANS OF THE NEPA (Water Scorpion).—1, The head. 2, Base of the feet of the first pair. 3, First ring of the thorax. 4, Base of wings. 5, Base of the feet of the second pair. 6, Stigmata. 7, Tracheæ. 8, Aerial vesicles.

SYNTHETIC TOPICAL REVIEW.

Larynx,	§ 37. *Anatomy of.*	CHAP. X. *The Respiratory and Vocal Organs.*
" its parts,		
Trachea,		
Bronchi,		
Lungs.		
Larynx,	§ 38. *Histology of.*	
Vocal Cords,		
Trachea,		
Bronchi,		
Lungs,		
Pleura.		
Respiration,	§ 39. *Chemistry of.*	
Carbonic Acid,		
Exchange of Oxygen and Carbonic Acid,		
Expired and inspired air,		
Animal heat.		
Respiration, object of	§ 40. *Physiology of.*	
" modes of		
Renovation of air in air-cells,		
Amount of air in respiration,		
Number of respirations,		
Modifications of respiratory movements,		
Larynx, double function of		
Vibration of the Vocal Cords,		
Conditions affecting tones,		
" " strength of voice.		
Circulatory System, care manifested in	§ 41. *Hygiene of.*	
Pure blood, how obtained,		
Carbonic Acid, its influence,		
" its sources,		
Dwelling-houses, location,		
" impure air in		
Public Buildings, ventilation,		
Sleeping-rooms, "		
Sick-rooms, "		
Pure air and warmth, how obtained,		
Importance of moisture,		
Compression of respiratory organs,		
Enlargement of the chest,		
Influence of nervous system.		
Mammalia, Respiratory Organs of	§ 42. *Comparative Pneumonology.*	
Birds, " "		
Reptiles, " "		
Amphibians, " "		
Fishes, " "		
Annulosa, " "		
Mollusca. " "		

Give the Anatomy, the Histology, the Chemistry, the Physiology and the Hygiene, Human and Comparative, of the Organs of Respiration.

Fig. 142.

Fig. 142. A Representation of the Brain, Spinal Cord and Spinal Nerves.—1, The cerebrum. 2, The cerebellum. 3, 3, Spinal cord. 4, The sciatic nerve.

A. Distribution of the Olfactory Nerve.—1, 2, Nerve of smell.

B. Optic Nerve.—15, The nerve of vision.

C. The Gustatory Nerve.—1, 2, 3, 4, Branches of the nerve of taste.

D. Auditory Nerve.—13, Nerve of hearing.

DIVISION IV.

SENSORIAL APPARATUS.

391. In the two preceding Divisions, the tissues and organs directly involved in the movements of the body, and those most intimately connected with the preparation and assimilation of nutrient material, have been briefly described. In the present Division we consider the organs through which is manifested the subtle power that controls these motions and processes, establishes telegraphic communication between the several parts of the body and brings it into important relations with the external world. These, taken collectively, we name the *Sensorial Apparatus.*

CHAPTER XI.

NERVOUS SYSTEM.

§ **43.** Anatomy of the Nervous System.—*Two Forms of Nervous Tissue. Classification of the Ganglia, Nerves and Commissures. Spinal Cord. Medulla Oblongata. Peduncles of the Cerebellum—Of the Cerebrum. Corpora Striata. Optici Thalami. Corpora Quadrigemina. Corpus Callosum. Ventricles. Hemispheres of the Cerebrum. Convolutions of the Cerebrum and Cerebellum. Classification of Cerebro-Spinal Nerves—Of Cranial Nerves—Spinal Nerves. Sympathetic System. Distribution of Sympathetic Nerves.*

392. Nervous Tissue presents two formal characters—one, cell-like and gray in color; the other, fibrous and white. The former is arranged in masses called *Centres* or *Ganglia,* being the originating, active centres of nerve-force; the latter, in threads, which are simple conductors of nerve-force, and

are named *Nerves* when they connect the ganglia with the various parts of the body, and *Commissures* when they connect the ganglia with each other.

393. For convenience in study, the numerous Ganglia, Nerves and Commissures may be arranged in two great and closely-connected systems—the *Cerebro-Spinal* and the *Sympathetic*, the Cerebro-Spinal system including the series of ganglia within the skull and spinal column, their nerves, commissures and the lesser ganglia in the nerve-tracts; the Sympathetic system including the long chain of ganglia lying in front of the spinal column, their nerves, commissures and additional ganglia found chiefly in the abdominal cavity. (Figs. 151, 152.)

394. The Cerebro-Spinal Axis commences with that portion of nervous matter which lies within the spinal column, extending from the second lumbar vertebra to the base of the skull, and known as the *Spinal Cord.* It contains within itself the filaments of all the nerves of the external parts of the trunk and limbs. It is soft, and white externally, but grayish within, forming the longest ganglion in the system. The cord is nearly cylindrical and double, the two halves connected by a narrow commissure or bridge of the same substance as the cord, having within, through the entire length, a minute *central canal.* (Fig. 143.) On each half are two slight longitudinal lines, serving to distinguish it into *Anterior, Lateral* and *Posterior columns.* As it enters the cavity of the skull, the cord becomes enlarged and receives the name of *Medul'la Oblonga'ta.*

Fig. 143.

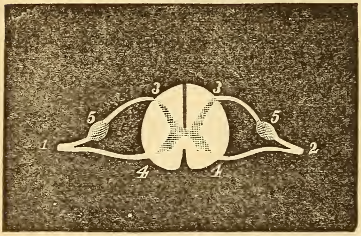


Fig. 143. Transverse Section of Spinal Cord.—1, 2, Spinal nerves of right and left sides, showing their two roots. 4, Origin of anterior root. 3, Origin of posterior root. 5, Ganglion of posterior root.

This enlargement is due to the presence of an important ganglion imbedded within, named the *Ganglion of the Medulla Oblongata,* and also to the accession of the fibres of most of the cranial nerves. In each of the lateral halves of the medulla oblongata may be seen four principal bundles of nerve-fibres, ranging backward from the middle line in front as follows: 1st, *Anterior Pyramids;* 2d, the *Olivary Bodies;* 3d, the *Restiform Bodies;* and 4th, the *Posterior Pyramids.* These bodies are continuous with their corresponding portions of the columns of the spinal cord. Many of the fibres of the anterior pyramids cross each other, bringing each side of the column into communication with the opposite side of the brain; this crossing forms the *Decussation of the Anterior Pyramids.* (Fig. 144.) Some of the fibres of the posterior pyramids also cross a little above. By the divergence of the restiform and posterior pyramidal bodies, a somewhat broad cavity is left, which may be considered a widening of the central canal, and which receives the name of the *Fourth Ventricle.* (Figs. 145, 146.)

Fig. 144.

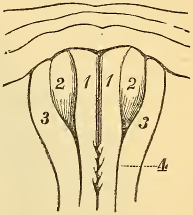


Fig. 144 (*Dalton*). Medulla Oblongata of Human Brain, anterior view. 1, 1, Anterior pyramids. 2, 2, Olivary bodies. 3, 3, Restiform bodies. 4, Decussation of the anterior columns. The medulla oblongata is seen terminated above by the transverse fibres of the Pons Varolii.

395. Overshadowing this ventricle is a mass of nerve-substance, called the *Cerebel'lum* or *little brain,* which is also double, consisting of two hemispheres. Each hemisphere, from its inner surface, sends out a multitude of fibres, which pass downward and forward toward the centre, unite into flattened bundles, emerge from the hemisphere, sweep across the base of the brain, pass up to the other hemisphere and spread out over its internal surface, thus originating in one hemisphere and terminating in the other. The two sets of fibres cross in front of the Medulla Oblongata, in the middle line of the base of the cerebellum, forming *the bridge of the Cerebellum,* or the *Pons Varo'lii.* (Figs. 144, 146.)

At the pons, the medulla oblongata sends off from the restiform bodies bundles of fibres called the *Inferior Peduncles of the Cerebellum.* Passing under and among the fibres of the pons and imbedding the *Ganglion of the Tuber Annula're* are two bundles—one of fibres from the anterior pyramids and the front of the olivary bodies, the other from the posterior

FIG. 145.

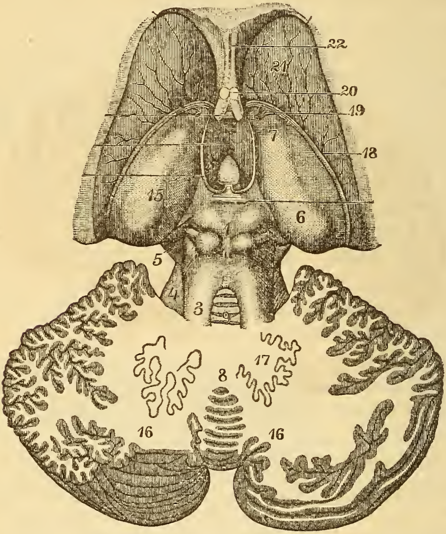


FIG. 145. STRIATED BODIES, THALAMI, QUADRIGEMINAL BODY AND CEREBELLUM.—1, Quadrigeminal body. 3, Superior peduncle of the cerebellum. 4, Superior portion of the middle peduncle. 5, Superior portion of the crus or leg of the cerebrum. 6, Posterior tubercle of the thalamus. 7, Anterior tubercle. 8, Fundamental portion of the cerebellum. 15, Thalamus. 16, Hemispheres of the cerebellum. 17, Dentated body. 18, Semicircular line. 19, Vein of the striated body. 20, Anterior crura of the fornix. 21, Striated body.

pyramids and the back of the olivary bodies; as they appear in front they diverge, forming stalk-like bundles known as the *Peduncles of the Cerebrum,* as they seem to support the

two hemispheres of the *cere'brum* or *brain proper.* The *anterior* bundles pass upward to the two large ganglia (one on each side of the median line), called the *Cor'pora Stria'ta* or *Striated Bodies;* the *posterior* bundles also pass upward to two ganglia situated a little in front of the striated bodies, and named the *Op'tici Thal'ami.* In these ganglia the fibres seem to terminate, while a new set connects the ganglia with the main surface of the cerebral hemispheres. (Fig. 145.)

Fig. 146.

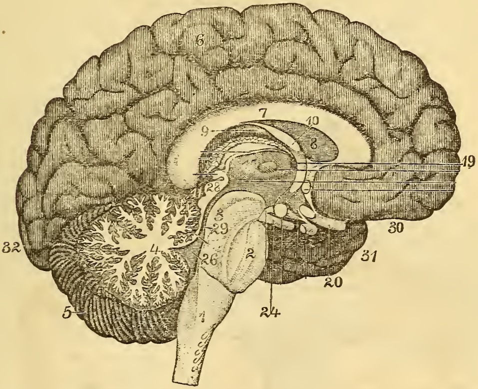


Fig. 146. Section of the Brain along the Great Longitudinal Fissure.—1, Medulla oblongata. 2, Pons. 3, Crus of the cerebrum. 4, Arborescent appearance in the cerebellum. 5, Left hemisphere of the cerebellum. 6, Inner surface of the left hemisphere of the cerebrum. 7, Corpus callosum. 8, Pellucid septum. 9, Fornix. 10, Anterior crus of the fornix. 19, Foramen of communication between the third and lateral ventricles. 20, Optic nerve. 24, Oculo-motor nerve. 26, Fourth ventricle. 28, Quadrigeminal body. 29, Entrance from the third to the fourth ventricle. 30, 31, 32, Anterior, middle and posterior lobes of the cerebrum.

It will be noticed that these ganglia have an unbroken connection with the spinal cord through the peduncles of the cerebrum and the fibres of the medulla oblongata.

Extending backward from the optic thalamus is a body divided on its upper surface into four eminences, hence called the *Corpora Quadrigemina* or the *Quadrigeminal body.* It

consists of four small ganglions, sometimes named *Optic Ganglions* (as they send nerves to the eye); which are attached to the peduncles of the optic thalamus, to the cerebellum and cerebrum, and to the medulla oblongata. (Fig. 145.)

396. All the above-mentioned ganglia are variously connected with each other, with the peduncles of the cerebrum and cerebellum, and, through the medulla oblongata, with the spinal cord.

397. The hemispheres of the cerebrum are closely united in their central part by a transverse commissure, called the *Corpus Callosum*. It forms the roof of a large central cavity between the two ganglia, corpora striata, the cavity being divided by a thin double membrane (the pellucid septum) into two communicating apartments called the Lateral Ventricles. The floor of the lateral ventricles forms the roof of the *Third Ventricle*, which is a narrow cavity between the optic thalami, communicating with the fourth ventricle, lying below and back of it, by a narrow passage-way. Hence it appears that the lateral ventricles, in the centre of the cerebrum, communicate with each other and with the third ventricle, the third with the fourth, and the fourth with the central canal of the spinal cord, making one unbroken communication through the whole extent. (Fig. 146.)

Fig. 147.

Fig. 147 represents a Convoluted Cerebral Hemisphere.—*a*, *a*, The scalp turned down. *b*, *b*, *b*, The cut edge of the bones of the skull. *c*, The external membrane of the brain (dura mater) suspended by a hook. *d*, The left hemisphere of the brain.

398. The *hemispheres of the cerebrum* enclose all the other parts, in front, above and behind, like a great overshadowing dome. Their outer surface is of gray matter, hence they are essentially two connected ganglia, and the largest in the system. Each hemisphere is marked off by fissures into three lobes—the frontal, middle and posterior lobe or ganglion, the frontal being the largest, and there is a little offshoot of the frontal lobe, called the *Olfactory*. Each of these lobes has its surface moulded into many tortuous and complicated elevations of the cerebral substance, termed *Convolutions*, which are marked off from each other by secondary winding fissures, named *Sulci;* thus there is formed "one unbroken but undulating sheet" over the whole surface of the brain. (Figs. 146, 147.)

399. The *general plan* of convolutions in the two hemispheres is the same, but in detail there is want of exact symmetry. It is a remarkable fact that the higher the mental development, the more unsymmetrical and complicated are the convolutions, and the deeper the depressions or sulci.

400. The cerebellum, like the cerebrum, has its hemispheres marked off into lobes. The lobes are highly subdivided on their sides and surface into thin plates or laminæ by cresentic furrows or sulci. The white fibres within the cerebellum are so arranged that when a vertical section is taken it presents the appearance of the trunk and branches of a tree, and hence it bears the name of *Arbor Vitæ*. (Fig. 146.)

401. The parts already described, viz., the brain and spinal cord, constitute the *Cerebro-spinal Axis*, from which proceed

THE NERVES OF THE CEREBRO-SPINAL SYSTEM.

402. Certain of these nerves conduct nerve-force *from* the ganglia to their own distal ends in the tissues, chiefly muscular, where motion is produced. Other nerves carry impressions from their extremities *to* the centres; the first are termed *Motory* from their function, and *Efferent* from the direction of conduction; the second are termed *Sensory* and *Afferent*. The anterior fibrous bundles of the medulla ob-

Fig. 148.

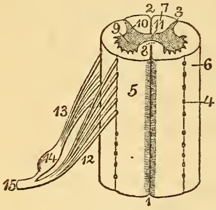


Fig. 148. Segment of the Spinal Cord.—1, Anterior median fissure. 2, Posterior median fissure. 3, Postero-lateral fissure. 4, Antero-lateral fissure. 5, Anterior column. 6, Lateral column. 7, Posterior column. 8, Anterior commissure. 9, Anterior horns of the gray substance. 10, Posterior horns. 11, Gray commissure. 12, Anterior root of a spinal nerve springing by a number of filaments from the antero-lateral fissure. 13, Posterior root from postero-lateral fissure. 14, Ganglion on the posterior root. 15, Spinal nerve formed by the union of the two roots.

longata, passing upward to the corpora striata, form a *Motor Tract*, so distinguished by the endowments of the nerves that issue from it; the posterior bundles, passing to the Thalami Optici, form a *Sensory Tract.* (Figs. 149, 150.)

403. The Cerebro-spinal nerves are also distinguished as *Cranial* nerves when they pass directly from the brain through openings in the cranium, and as *Spinal* when they issue from the vertebral openings of the spinal column.

The Cranial Nerves are arranged in twelve pairs, named numerically, counting from before backward, or from their function, destination or specific character. They may be arranged in three groups, according to their functions, as *Sensory*, *Motory* and *Mixed.*

Observation.—A nerve is said to originate by a single root when its bundles of fibres emanate from one spot or along the same line of the cerebro-spinal axis, and it is said to arise by two or more roots when its bundles of fibres form a corresponding number of series emanating from different points of the cerebro-spinal axis.

The fibres composing the roots of the nerves are traceable into the substance of the brain and spinal cord, within which they are continuous with nerve-fibres of the white substance, or become connected with the neighboring gray substance. This interior connection of the nerves is called their deep origin, while their exterior connection with the cerebro-spinal axis is named their superficial origin.

To ascertain the real origin of the nerves is among the most difficult subjects of anatomical investigation, and our knowledge in this respect is very imperfect.

FIG. 149.

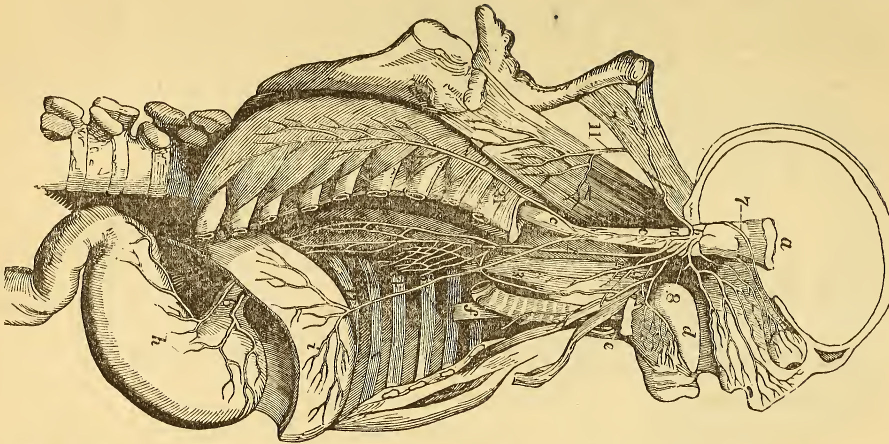


FIG. 149. DISTRIBUTION OF PNEUMOGASTRIC NERVES.—*a*, Section of the brain and medulla oblongata. *b*, The lateral columns of the spinal cord. *c*, *c*, The respiratory tract of the spinal cord. *d*, The tongue. *e*, The larynx. *f*, The bronchia. *g*, The œsophagus. *h*, The stomach. *i*, The diaphragm. 1, The pneumogastric nerve. 2, The superior laryngeal nerve. 3, The recurrent laryngeal nerve. 4, The pulmonary plexus of the tenth nerve. 5, The cardiac plexus of the tenth nerve. 7, The fourth pair of nerves. 8, The facial nerve. 9, The glosso-pharyngeal nerve. 10, The spinal accessory nerve. 12, The phrenic nerve. 13, The external respiratory nerve.

404. Cranial Nerves.

Group	Pair	Name	Origin	Destination
1st Group. *Sensory.*	1st pair	Olfactory	Olfactory ganglia	Mucous membrane of nasal passages.
	2d "	Optic	Optic "	Retina of eye.
	8th "	Auditory	Medulla oblongata	Internal ear.
2d Group. *Motor.*	3d pair	Oculo-Motor	Cerebral peduncles	The muscles of eye, excepting external rectus and trochlear.
	4th "	Patheticus	" "	Trochlear muscle of eye.
	6th "	Abducent	Pons and medulla oblongata	External rectus " turning eye upward.
	7th "	Portio Dura	Medulla oblongata	Different muscles of face, giving expression.
	12th "	Hypo-glossal	" "	Muscles of tongue.
	11th "	Spinal Accessory	Spinal cord, low in the neck	Muscles of neck.
3d Group. *Mixed.*	5th pair	Trifacial	Pons Varolii	Motor branches to muscles used in mastication. Sensory " the teeth, tongue and different parts of the face. (Fig. 165.)
	9th "	Glosso-pharyngeal	Medulla oblongata	Mucous membrane of the tongue and throat.
	10th "	Pneumogastric	" "	Motor branches to the pharynx, larynx, trachea, lungs, heart, œsophagus, stomach and intestines. Sensory to ditto. (Fig. 149.)

Fig. 150.

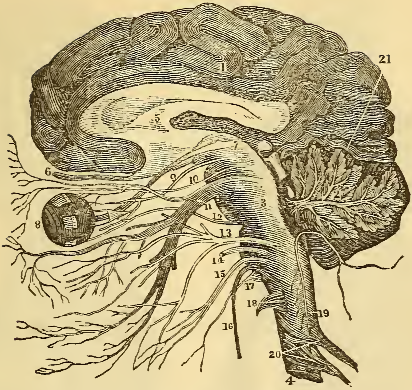


Fig. 150. A Vertical Section of the Cerebrum, Cerebellum and Medulla Oblongata, showing the relation of the cranial nerves at their origin.—1, The cerebrum. 2, The cerebellum with its arbor vitæ represented. 3, The medulla oblongata. 4, The spinal cord. 5, The corpus callosum. 6, The first pair of nerves. 7, The second pair. 8, The eye. 9, The third pair of nerves. 10, The fourth pair. 11. The fifth pair. 12, The sixth pair. 13, The seventh pair. 14, The eighth pair. 15, The ninth pair. 16, The tenth pair. 19, The eleventh pair. 18, The twelfth pair. 20, Spinal nerves. 21, The tentorium.

405. The Spinal Nerves are arranged in thirty-one pairs, and (unlike the cranial nerves, excepting the Trifacial) each arises by two roots—an anterior or *Motor* root, springing from the anterior columns of the spinal cord, which are continuous with the *Motor tract* before mentioned; and a posterior or *Sensitive* root, from the posterior columns of the spinal cord, and continuous with the *Sensory tract.* The Sensitive roots are larger than the Motor, and each has an imbedded ganglion, after the formation of which the two roots unite into one trunk, forming the spinal nerve, which passes out of the spinal column through the invertebral openings.

406. The Spinal Nerves are divided into—

Cervical	8	pairs.
Dorsal	12	"
Lumbar	5	"
Sacral	6	"

Fig. 151.

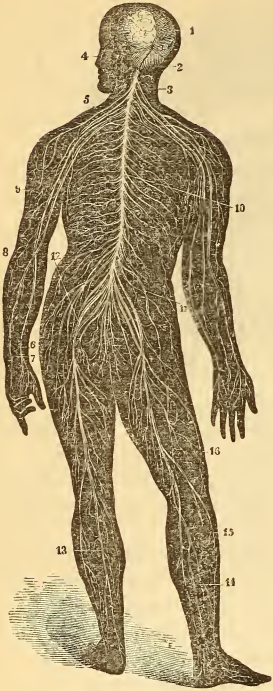


Fig. 152.

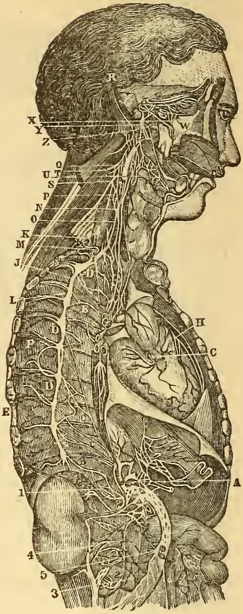


Fig. 151. A Back View of the Brain and Spinal Cord.—1, The cerebrum. 2, The cerebellum. 3, The spinal cord. 4, Nerves of the face. 5, The brachial plexus of nerves. 6, 7, 8, 9, Nerves of the arm. 10, Nerves that pass under the ribs. 11, The lumbar plexus of nerves. 12, The sacral plexus of nerves. 13, 14, 15, 16, Nerves of the lower limbs.

Fig. 152 represents the Sympathetic Ganglia and their Connection with other Nerves.—A, A, A, The semilunar ganglion and solar plexus. D, D, D, The thoracic (chest) ganglions. E, E, The external and internal branches of the thoracic ganglions. G, H, The right and left coronary plexus. I, N, Q, The inferior, middle and superior cervical (neck) ganglions. 1, The renal plexus of nerves. 2, The lumbar (loin) ganglion. 3, Their internal branches. 4, Their external branches. 5, The aortic plexus of nerves.

At some parts of their course certain branches of the nerves

reunite, forming networks called *plexuses*. Thus the four upper cervical nerves anastomose, forming the *cervical plexus*, at the side of the neck; the four lower cervical and the upper dorsal form the *brachial* plexus, from which proceed six nerves which ramify upon the muscles and skin of the upper extremities; the last dorsal and four lumbar nerves form the *lumbar plexus*, which sends off six nerves to ramify upon the muscles and skin of the lower extremities; the last lumbar and four upper sacral form the *sacral plexus*, which distributes nerves to the muscles and skin of the hip and lower extremities. (Fig. 151.)

THE SYMPATHETIC NERVOUS SYSTEM.

407. The Sympathetic system, like the Cerebro-Spinal, is double, consisting of two chains of ganglia, one on each side of the spinal column, running through the deep parts of the neck, into the chest and abdomen. These ganglions communicate with each other, with the spinal cord and with the internal organs—as the heart, lungs, stomach, liver, pancreas, intestines and kidneys. In the neck and chest the ganglia are arranged in pairs; those of the neck are three in number and the largest of the system; those of the chest, twelve in number, a ganglion resting upon the head of each rib; in the abdomen the arrangement is irregular. (Fig. 152.)

408. A peculiarity of the Sympathetic nerves is, that they *follow the distribution of the blood-vessels*. Starting from the heart, they envelop the large vessels with a close network, called the *Arterial plexus;* and in the abdomen, behind the stomach, the large blood-vessels are surrounded by many small ganglia, all united by networks of fibres called the *solar plexus*, because the other plexuses of the abdomen radiate from it, like the rays diverging from the sun. In all parts of the body these nerves accompany the arteries which supply the different organs, and form networks around them which take the names of the organs—as the hepatic plexus, splenic plexus, mesenteric plexus, etc.

§ **44.** Histology of the Nervous System.—*Three Microscopic Elements of Nerve-Tissue. Nerve-Cells. Nerve-Fibres. Membranes of Cerebro-Spinal System.*

409. Nervous Tissue is composed of three microscopic elements—*Nerve-Cells* or *Ganglionic Corpuscles, White* or *Tubular Fibres* and *Gray* or *Gelatinous Fibres.*

410. The Nerve-Cells are *nucleated* cells; that is, vesicular matter containing, besides a pulpy substance, an eccentric, roundish body or *nucleus,* enclosing one or more *nucleoli* surrounded by colored granules (Fig. 153). These nerve-cells have various branches or offsets starting from any part of the cell-wall and completely continuous with it and with the contents of the cell itself. The branches connect the cells with each other, and also with the nerve-fibres. Their number varies from one to twenty, and the cells are accordingly distinguished as *unipolar, bipolar* and *multipolar* (Fig. 10). A collection of nerve-cells constitutes the essential part of a *Ganglion.* They are imbedded in a matrix of fine, soft, granular matter, and variously mingled and interwoven with multitudes of fibres. Composed of such masses do we find the whole convoluted surface of the brain, the thalami optici, the corpora striata, the quadrigeminal body and some other minute bodies; from these, one unbroken gray tract may be traced through the interior of the peduncles of the brain, the interior of the medulla oblongata and of the spinal cord. The various ganglia of the sympathetic system are also of the same substance.

Fig. 153.

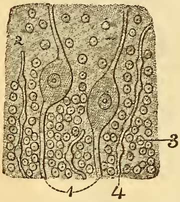


Fig. 153. Portion of Gray Substance, from the Exterior of the Cerebellum.—1, Two nerve-cells with bipolar prolongations. 2, Granular matter. 3. Nuclear bodies. 4, Nerve-fibres.

411. The White or Tubular Fibres, or the ultimate nerve-filaments, consist of an outer, structureless membrane enclosing a layer of transparent fluid fat, or medullary matter, within which is a firmer part—a gray, ribbon-like thread, called the *central band-axis,* or the *axis cylinder.* This is

identical in structure with the processes of the nerve-cells with which it is continuous, and is very important, as it is sometimes the only part of the nerve-fibre left within the structureless sheath, thus constituting the so-called *pale, non-medullated* nerve-fibre. As the medullary matter encloses the band-axis, it is often, though improperly, called the *medullary sheath.*

FIG. 154.

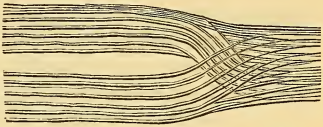


FIG. 154. NERVE-FILAMENTS, decussing with their sheath.

412. The nerve-filaments are distributed to the skin, muscles and glandular organs in all parts of the body. From these points they approach each other, uniting into little bundles or fibres, and then into larger bundles, till they are of sufficient size to be seen by the naked eye, when they constitute a *nerve.* The filaments do not blend with each other, but lie in simple juxtaposition, each retaining a complete individuality from its origin to its termination. Like the fibres of a muscle, they are bound together and protected by a covering of areolar tissue, called its *Neurilem'a* or sheath, which also contains the blood-vessels for the nutrition of the nerve. The filaments become gradually finer toward their outer extremities, till at length the sheath, medullary portion and band-axis

FIG. 155.

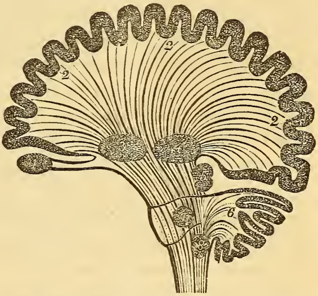


FIG. 155. DIAGRAM OF HUMAN BRAIN, IN VERTICAL SECTION, showing the situation of the different ganglia and the course of the fibres.—1, Olfactory ganglia. 2, Hemisphere. 3, Corpus striatum. 4, Optic thalamus. 5, Tubercula quadrigemina. 6, Cerebellum. 7, Ganglion of tuber annulare. 8, Ganglion of medulla oblongata.

become undistinguishable. Their mode of termination is uncertain, though the sensory nerves, at least, seem to have free extremities.

413. The tubular fibres compose the white parts of the brain and the spinal cord, the chief substance of the nerves, and also pass into and mix with the gray substance of the brain, cord and all the ganglia. They vary in size, being finest of all in the superficial layers of the brain, fine in the nerves of special sense and in the ganglia, larger in the fore part of the spinal cord, and largest in the motor nerves.

414. Besides the White tubular fibres, there are found, chiefly in the Sympathetic System, GRAY or GELATINOUS FIBRES, which are flattened, more minute than the white fibres, and greatly resembling their band-axis. Some have considered these but a form of connective tissue, but whether they be so considered, or as true nervous elements, they seem to be produced by the coalescence of elongated nucleated cells, the contents of which, as the cells enlarge, become soft and finely granular, while the nuclei appear wider and wider apart.

415. The MEMBRANES of the Cerebro-Spinal System are four in number—the *Dura Mater*, the *Pia Mater*, the *Arach'-noid Membrane* and the *Epen'dyma.* The Dura Mater is a tough, fibrous membrane lining the bony walls of the skull and spinal column, forming their *periosteum.* The Pia Mater is another fibrous and very vascular membrane which closely invests the brain and spinal cord and sends processes into all their fissures. The inner surface of the dura mater and the outer surface of the pia mater, each becomes very delicate in structure, and are lined with an epithelium; this gossamer membrane is named the Arachnoid Membrane. Its two layers unite at many points, thus forming closed sacs, which, like other serous membranes, secrete a fluid called the *arachnoid fluid.*

416. The dura mater not only firmly invests the brain and spinal cord, but sends off supporting partitions, that which descends between the hemispheres of the cerebrum being

called the *Cerebral Falx;* that between the hemispheres of the cerebellum, the *Cerebellar Falx;* and that between the cerebrum and the cerebellum, the *Tentorium.* Through separations in the layers of the dura mater channels are formed, performing the office of veins; they are named *Sinuses of the Dura Mater,* and are lined with a continuation of the ordinary epithelium of blood-vessels. The dura mater also furnishes the areolar sheaths to the several cranial and spinal nerves; therefore it is continuous from the lining of the cranium to the extremity of the nerves in the different parts of the body.

417. The *Ependyma* is a delicate, transparent, serous membrane, lining the ventricles of the brain and the central canal of the spinal cord.

§ **45.** Physiology of the Nervous System.—*Relation of the Nervous System to this Nature. Man's Compound Nature. The Rank of the Nervous System. Relation of the Nervous Centres to the Sensitive and Motor Nerves. Classification of the Centres. System of Dependencies. General Function of the Organic Centres. Their Modes of Reflex Action. Peculiarity of Sympathetic Action. Functions of the Reflex or Spinal Centres. Their Acquired Action and the Theory explaining it. Practical Importance of the Automatic Tendency produced by Repetition and Association. Character of the Sensational Centres and their Action. Internal Stimuli to the Activity of these Centres. Functions of the Ideational Centres. Ideas suggested by the same Object different in different Individuals. Various Manifestations of Reflex Action in the Ideational Centres. Emotional Character of these Centres. Volitional Character. Relation of the Emotions to the Will. Influence of the Physical Nature for Good or for Evil. The Language of the Muscles.*

418. The Nervous System is the border-land where the material touches the immaterial. It possesses that highest refinement of physical organization through which the mind may manifest itself, and by means of which it may control and bring into service not only the various organs of the body, but other matter more external and remote.

Observation.—At different periods of the world's history many different opinions have prevailed concerning the respective existence of *body* and *soul* and their relations to each other. The pagan Greek included all under the one word *ψυχή* and the Roman under that of *anima,* which

was almost "equally applicable to the vegetable life of a cabbage, the animal life of a sheep and the spiritual life of an apostle." During the fifth century before the Christian era, Anaxagoras advanced a shadowy idea of man's compound nature, which at the day-dawn of Christianity assumed a clear and definite outline. At length, philosopher and Christian advocated the supremacy of the immaterial nature over the material, and eventually regarded their interests as antagonistic. The body was deemed the source of all evil, the work of the Prince of Darkness. At the present day more than at any former period efforts are being made to rightly balance the two natures, and yet many seem to regard the body as a gloomy prison-house in which God has shut us up, rather than as a beautiful "temple" in which the mind and soul may dwell as priest and priestess, using all its appointments in rendering service to the Lord of the temple.

419. The organisms heretofore described have no *inherent* active power, but are entirely dependent upon the nervous system; thus, the bones are dependent for movement upon the contractility of the muscles, this contractility upon the stimulus of the nerves, this stimulus upon the energetic action of the nerve-centres, and these centres are graded in rank and measurably dependent, the lowest upon the next higher, and so on to the highest or convoluted centres of the hemispheres.

420. In their function the *nervous centres* are intermediate between the sensitive and motor fibres; as the sensitive fibres, being acted upon at their distal extremities, convey impressions *inward to the centre,* and the motor fibres, being acted upon at the centres, convey nerve-force *outward* and produce motion *at their distal extremities.* Let any part of the surface of the body be touched by a hot iron, and muscular contraction instantly follows, but there has been time enough for the sensation of pain to be conveyed to the nervous centre, and for an impulse to be sent from that centre to the muscles: such action is called the *Reflex Action of the Nervous System.* By this means a communication is established between the different organs. This communication is never direct, but from one organ inward to the nervous centre, then outward to another organ; so are the different functions associated and exercised for the common good of the whole.

421. In dealing with the functions of the Nervous System we adopt the following classification of the Nervous Centres, viz.: 1st, The *Primary* or *Ideational* Centres, comprising the gray matter of the convolutions of the hemispheres. 2d, The *Secondary* or *Sensational* Centres, comprising the gray matter between the floors of the lateral ventricles and the decussation of the pyramids. 3d, The *Tertiary* Centres, or Centres of *Reflex Action*, comprising the gray matter of the spinal cord. 4th, The *Quarternary* or *Organic* Centres, comprising the gray matter of the Sympathetic System.

Observation.—The arrangement of this system of centres is like that of a well-ordered body politic. Each distinct department or nerve-centre acts independently within certain limits, but beyond these limits it is subordinate to the next higher; thus, the Organic Centres are subordinate to the Reflex or Spinal Centres, the Reflex to the Sensorial, and all to the Ideational or Supreme Centres. In each centre the individual cells probably differ in rank, some having a higher dignity, some a lower, but each its special appointment, its assigned duty.

422. The Organic or Sympathetic Centres are not well understood, but the distribution of their nerves would indicate that they exercise a controlling influence over the involuntary functions of digestion, absorption, circulation and assimilation. From the fact that these nerves reach their ultimate destination supported on the arterial vessels, it is probable that their influence is exerted through a certain control over the muscular coat of the heart and arteries, thus hastening or retarding the course of the blood, and increasing or diminishing its quantity in various organs. Thus the functions of nutrition, secretion, etc., depending so much upon the state of the circulation, are made to sympathize with each other very closely; hence the name "Sympathetic" System.

423. The organic centres, being connected with the various organs by sensitive and motor nerves, are capable of an *independent reflex action.* They are also connected with the cerebro-spinal system, and are more or less assisted by and subordinate to it. In health the brain takes no cognizance of their action; when diseased, however, the centres report to

the highest authority by means of cramps and other severely acute pains. In its normal action a centre seems to expend only so much force as is disposed of by the motor nerves; in diseased action there is a surplus, which is conveyed to the next highest centre, to be disposed of by its motor nerves; if there is still a surplus, it passes on as before.

424. There are *three kinds of reflex action* taking place either wholly or partially through the Sympathetic System, viz.: 1st, The reflex action from the internal organs to the voluntary muscles and sensitive surfaces; examples are seen in the convulsions of children, caused by the irritation of undigested food in the intestines, and in adults in the attacks of temporary blindness or confused vision so often accompanying indigestion. 2d, The reflex action from the sensitive surfaces to the involuntary muscles and the internal organs; as mental and moral impressions received by the senses disturb the motions of the heart and affect the circulation, digestion and secretion, disagreeable sights or odors produce nausea and other functional derangements. 3d, The reflex action between the internal organs, as the associated action of the stomach, liver, etc. The variation in the capillary circulation of the abdominal viscera, according as they are active or inactive, is probably referable to a similar influence.

Observation.—One marked peculiarity of the Sympathetic System is, that its nerves and ganglia act with much less rapidity than those of the Cerebro-spinal System; hence, inflammation of the internal organs is not manifest for several hours after the application of the exciting cause, as the effects of a chill or cold do not usually follow immediately after the exposure. Because of this tardy action the effect remains long after the cause is removed.

425. The Tertiary, Reflex or Spinal Centres. The white, tubular substance of the spinal cord connects the muscles and integuments below with the brain above, and thus assists in the production of conscious sensation and voluntary motion. The gray matter forms nerve-centres, which *exert a general protective influence over the whole body.* They *preside over the involuntary movements of the limbs and trunk;* if a

finger touch a heated surface, it is suddenly withdrawn, and that without effort of the will, and often in opposition to it. They *regulate the action of the sphincter muscles,* as in the rectum and bladder. They *exercise a certain control over the changes of secretion, nutrition, etc.,* as is manifest in cases of disease. Thus we see that many human activities are performed by the *reflex action* of the *spinal centres,* inherent in their *natural* constitution.

Observation 1.—They are, however, capable of an *acquired* reflex action which is matured through experience. An act or an association of acts becomes easier to them by repetition. This acquired power of reflex action has been accounted for by a theory * which is at least beautifully *illustrative* of the *facts* in the case. Every display of energy in the nerve-cells causes a change or waste of nervous element which is repaired by nutrition. This theory assumes that the *character of the waste determines the character of the deposit;* that the particle deposited is necessarily *endowed* according to the particular kind of activity manifested, and that this endowment *inclines* the particle to the *same kind* of activity again. By each repetition the *tendency* becomes stronger and more definite, till, after a longer or shorter series of repetitions, the action becomes *automatic.*

2.—When a certain class of movements have, after many voluntary efforts, become *associated,* they become perceptibly more and more easy. Walking is at first a very conscious and voluntary act, but it may become so far reflex and automatic that one in a profound abstraction may continue to walk without being at all conscious where he is going, and when he wakes from his reverie may find himself in some other place than that which he intended to visit. Multitudes of our daily acts are the result of this acquired reflex action of the spinal centres. The wisdom of such an arrangement is very evident, for but little could be accomplished if acts became no easier by repetition and association.

3.—Conscious efforts of the will soon produce exhaustion, while the automatic acts of which we are speaking occasion comparatively little weariness. We often say of certain rounds of duties that they do not weary us, for we are *accustomed* to them. In speaking of this acquired power of which the spinal centres are capable, Dr. Maudsley says: "Like the brain, the spinal cord has its *memory.* A spinal cord without memory would be an *idiotic* spinal cord, incapable of culture—a degenerate nervous centre in which the organization of special faculties could

* Dr. Maudsley.

not take place. It is the lesson of a good education so consciously to exercise it in reference to its surroundings that it shall act automatically in accordance with the relations of the individual in his particular walk of life."

426. The SENSATIONAL CENTRES, including the gray matter of the medulla oblongata and of the base of the brain as far as the lateral ventricles, consist chiefly of the nervous centres of the higher or *special senses*, as sight, hearing, etc. Any one of these senses is quickly destroyed by destroying its ganglion; the loss of the quadrigeminal body destroys the sight as effectually as putting out the eyes. That these centres have an independent reflex action may be seen by the involuntary closure of the eyelid when a strong light falls upon the eye, or by the involuntary contortions of the face when an article is sour or bitter to the taste. These are examples of *natural* reflex action, but like the spinal cord, these centres are capable of an *acquired* reflex action, as in the articulation of words upon seeing their signs, adapting the movements of the body to the rhythm of music in dancing, marching, etc.

Observation 1.—Most of the sensations of the special senses become clear and definite only after a long course of training; for instance, the visual sensation of the adult is a very different matter from that of the child whose eyes have recently opened upon the world. "The sensation of the cultivated sense thus sums up, as it were, a thousand experiences, as one word often contains the accumulated acquisitions of generations."

2.—In speaking of the acquired reflex action of the spinal centres we referred to the theory that a *relic* or *residuum* of every activity remained in the nerve-cell as a special endowment; that perhaps the character of the activity determined the character of the nutritive deposit. This theory is equally applicable to the sensational centres, and equally illustrative of the certain fact that acts of this class are rendered easier by repetition.

427. The sensational centres are excited to activity not only by impressions from the organs of the special senses, but by sensations from *within the body*, both from the organic and ideational centres. Of the former examples are afforded when the higher nervous centres are weakened by disease or when

the organic stimuli have an unnatural activity, as is the case with the intemperate man.

428. The Ideational Centres seem to have the power of fashioning into ideas the impressions received by the sensational centres. When the various properties of an object are presented by the different senses these centres reject the unessential, and selecting the essential, mould them into an organic unity or idea.

Observation 1.—By means of the sensorial centres and nerves we may gain perceptions or impressions of the qualities of a rose, but these would be isolated, and we should have no clear and definite idea of the rose without the moulding and vivifying influences of the ideational centres.

2.—Different persons obtain very different ideas of the same object; the character of the idea being dependent upon the character of the organization both of the sensational and ideational centres, and the character of the organization upon natural endowment or *inherited organization,* and also upon the education received.

429. The ideational centres, like those already described, are capable of an independent reflex action, which may be manifested in different ways: 1st, This may take place *through the motor tract,* thus giving rise to what have been named *ideo-motor* movements. This energy may be exerted either upon the voluntary or involuntary muscles, and in the former case either with or without consciousness. Examples of the reflex action of ideas upon our voluntary muscles are seen every hour of our waking life; these may be unconscious, as is seen in most persons who talk to themselves, or they may be *conscious,* and yet without the intervention of the will, as when a quick-tempered individual quickly resents an insult by a blow. 2d, The reflex action of an ideational nerve-cell may not only operate downward upon the muscular system, but downward upon the *sensory centres;* the idea of a nauseous taste may excite the sensation to such a degree as to produce vomiting. 3d, Another very important reflex action of these centres is that which modifies the *secretions and nutrition;* a flow of saliva may be produced by the thought of food, or a flow of tears by a sympathetic idea. 4th, There may be in these

centres a reflex action *among the cells themselves.* One cell reacts to a stimulus from a neighboring cell, then transfers or *reflects* this energy to another. This may be the condition of activity among these cells during that process of the mind which we call *Reflection.*

430. These ideational centres are also the seat of the *Emotions.* When an idea is attended with some feeling, either pleasant or unpleasant, it is so far *Emotional;* and when the feeling *preponderates,* the idea is obscured, and the state of mind is then called an *Emotion,* or when rising above the ordinary degree and becoming impatient of restraint, a *Passion.*

431. Every centre of idea is also a centre of *Volitionary* reaction. When an idea acts *directly* downward, we call the effect *ideomotor;* but when there is deliberation or reflection delaying the action, and it afterward takes place downward, we call the effect *volitional.* Volition is also exercised in preventing as well as in producing an action.

432. The exercise of the *Will* is the highest energy of which the supreme centres are capable. Within certain limits, the ideas and emotions are subject to its control. Suppose a being endowed with the intellectual and emotional natures, but not with the will; though possessing the intelligence of a man, his capacities for action would be inferior to those of the brutes, for, like them, his actions would be the result of mere sensational impulses, and yet he would be destitute of that natural guide of brutes which we call *instinct.* This represents the wretched condition of a man whose will is by any means so enfeebled that it fails to control the mental and physical powers.

433. The *power* of the will depends both upon the inherited organization and also upon the training it has received, for volitions, like sensations and ideas, become more easy and definite by repetition. A naturally weak will may be greatly strengthened by due care and training. According to the theory before mentioned, each volition leaves its relic, trace or residuum which inclines the portion of nerve-element

exercised to a like activity again. If we accustom ourselves to decide promptly, to act energetically and to carry out our purposes in the many smaller and less important affairs of life, we gain a power of will which may be carried into higher departments of action and into circumstances of greater embarrassment and difficulty.

434. The Will bears very important relations to the *Emotions*. If they are allowed to react independently, as is their natural tendency, they weaken the will; if duly controlled and co-ordinated, they strengthen it. The passionate nature of the child may, by proper training, become a potent force for good in after years, "giving a white heat, as it were, to the expression of thought, an intensity to the will." Untrained, it will become a no less potent force for evil, and the individual under the mastery of his passions will be tossed about as helplessly as a boat in the rapids of Niagara.

Observation 1.—We have seen that the mind is closely *united* and yet distinct from the material organs through which it acts—dependent for its manifestations, but independent in essence. So intimate is the union that the body exercises a powerful influence in leading us upward into a true and higher life, or downward into a low and sensual existence. What this influence shall be depends somewhat upon inherited organization, but more upon education. Accepting the theory already advanced as at least illustrative, we see that if the thoughts, feelings and volitions are pure and true and good, their impressions or residua remaining in the nerve-cells are of the same character, and tend to give a right direction to the future activities of these cells. If the thoughts, feelings and volitions are evil in nature, the impressions or residua will also be evil, inclining to evil activities in the future. When we resist a temptation to wrong action, then we not only avoid the particular evil, but lay up that which will render the next resistance easier and more natural. If we yield to the temptation, we are not only guilty of the particular wrong, but lay up that which will make resistance more difficult or yielding more easy and natural for the future. When a man sets his *heart* to do right, all his physical being struggles to give him aid; and when he sets his heart to do wrong, its energies are expended in dragging him downward.

2.—The *visible impress* which the workings of the mind leave upon the body is worthy our notice. The character of the man is declared by the lines of his muscles, which tell no lies. Especially is this true

of the muscles of his face. Let him narrow his soul by penuriousness, become the victim of rasping jealousy, wear the nettles of envy against his heart, or be the slave of defiling lust, and in spite of any natural comeliness or studied concealment, his true character will be proclaimed to all who have learned aught of the language of the muscles. "Be sure your sin will find you out," says He who has made the fleshly lineaments to reveal the most hidden vice. The more secret the viciousness, the deeper is the impress. But if the spirit of evil thus leaves the traces of its blackened pen upon the face, the spirit of goodness writes thereon in no less legible characters of light. Purity of heart, nobleness of purpose, restfulness of soul, soften, irradiate, *spiritualize* the outer man, giving a higher beauty than that of form or complexion, even to him who is wrinkled by years, bowed by infirmity and scarred by the battles of life.

§ **46.** HYGIENE OF THE NERVOUS SYSTEM.—*Two Classes of Agencies affecting the Health of the Nervous System. Natural Heritage. Importance of the Physical Agency—Air—Diet—Exercise and Sleep. The Effect of Mental Impressions on the Body. Mental Exercise. Recreation and Amusement. Harmonious Development of the Different Mental Powers.*

435. We have seen that different organs of the body are entirely dependent for functional action upon the stimulus afforded by the nervous system; and since this is the material organization through which the mind acts, we are led to the inevitable conclusion that the physical condition of this system must affect, more or less, the *mental* manifestations. It becomes, then, a matter of primary importance that we understand the conditions essential to the health of this system, especially as suffering from nervous disease exceeds that of other diseases, as the delicacy of the organization exceeds that of other organizations of the body.

436. In considering the hygiene of the nervous system, it is necessary to have reference both to physical and mental agencies. The highest health and vigor of the nervous system doubtless require—1st, A sound nervous organization by inheritance; 2d, A nutrition equal to the demands of repair and growth; 3d, The harmonious action of the various mental powers.

437. 1st, A Sound Organization by Inheritance. "Each of us is only the footing-up of a double column of figures that goes back to the first pair," is the striking expression of a great truth. Every-day observation shows that children inherit not only the features, but the physical, mental and moral constitution of their parents. Even those utterly ignorant of the laws of transmission are wont to estimate the child according to its family; favorably, if of a "good family" or "good blood;" unfavorably, if of a "bad family" or "bad blood."

Every formation of body, internal and external, all intellectual endowments and aptitudes, and all moral qualities, are or may be transmissible from parent to child. If one generation is missed, the qualities may appear in the next generation. It is important to notice that not only the *natural constitution* of the parents may be inherited, but their *acquired habits* of life, whether virtuous or vicious, but especially is this true of vice. Even when the identical vice does not appear, there is a morbid organization and a tendency to some vice akin to it. Not only is the evil tendency transmitted, but what was the simple practice, the *voluntarily* adopted and cherished vice of the parent, becomes the passion, the overpowering impulse, of the child.

Illustration 1.—M. Morel sketches the history of four generations as follows: "*First Generation.*—The father was an habitual drunkard, and was killed in a public-house brawl. *Second Generation.*—The son inherited his father's habits, which gave rise to attacks of mania, terminating in paralysis and death. *Third Generation.*—The grandson was strictly sober, but full of hypochondriacal and imaginary fears of persecutions, etc., and had homicidal tendencies. *Fourth Generation.*—The fourth in descent had very limited intelligence, and had an attack of madness when sixteen years old, terminating in stupidity nearly amounting to idiocy; with him the race probably becomes extinct."

2.—Says a learned physician, after long and close observation of the evil effects of *tobacco:* "If the evil ended with the individual who, by the indulgence of a pernicious custom, injures his own health and impairs his faculties of mind and body, he might be left to his enjoyment, his *fool's paradise*, unmolested. This, however, is not the case. In no instance is the sin of the father more strikingly visited upon the chil-

dren than in the sin of tobacco-smoking. The enervation, the hysteria, the insanity, the dwarfish deformities, the consumption, the suffering lives and early deaths of the children of inveterate smokers bear ample testimony to the feebleness and unsoundness of the constitution transmitted by this pernicious habit."

3.—Should we trace the effects of the whole list of vices, it would be with equally sad results; even of the great love of money-getting, the celebrated Dr. Maudsley says: "I cannot but think, after what I have seen, that the extreme passion for getting rich, absorbing the whole energies of a life, does predispose to mental degeneration in the offspring, either to moral defect, or to moral and intellectual deficiency, or to outbreaks of insanity."

4.—Any kind of nervous disease in the parents, whether natural or acquired, seems to predispose to innate feebleness in the child. From this instability of nervous element, the slightest irritation often produces convulsions in the young child and loss of equilibrium in the adult. Such a natural constitution may be improved by a judicious education and strict obedience to physical and mental laws, but the original defect can never be entirely removed.

438. 2d, A NUTRITION EQUAL TO THE DEMANDS OF REPAIR AND GROWTH. The relation of the nervous centres to the blood is the same in kind as that between other parts of the body and their blood-supply. Great waste is produced by nervous action; hence, the centres are very largely supplied with blood-vessels, especially the Ideational centres. The activity of ideas is largely dependent upon the active flow of blood to the nerve-cells. Activity of thought invites the blood which, in turn, is so necessary to activity. The nerve-centres, then, must be supplied with the proper quality and quantity of blood; hence, whatever deteriorates the blood impairs the health of the nervous system. It is evident, then, that—

439. *The nervous system may be impaired by impure air.* Everybody knows that bad air injures the lungs, but few realize that, on the whole, it injures the brain still more. As the nerve-tissue is the most delicate part of the body, it soonest feels the evil effects of imperfectly oxygenated blood. (§ 40.)

440. *The nervous system may be impaired by improper diet.*

We are wont to believe that improper diet may affect the digestive organs, but seldom consider the *mental* and *moral* effects of such diet. Improper food poisons the blood, and thus the nerve-centres are cheated of their nutriment, and also poisoned; hence, the ideas become confused, the emotions morbid and the will weakened. The whole man is crippled, physically, mentally and morally. It is an indisputable fact that *bad bread*, for instance, may thus have a very *immoral* influence. Those much engaged in mental labor suffer most from bad diet. No teacher can teach well, no lawyer can plead well, no physician can practice well, no minister can think or preach well, who habitually takes improper food. (§ 21.)

Observation 1.—If such be the effect of improper food, what shall we say of such poisons as alcohol, opium, haschish, tobacco, etc., which act so directly and powerfully upon the nervous system? The same poison does not equally affect all the nerve-centres; thus, *strychnine* acts upon the spinal centres, but not the cerebral; *haschish*, upon the sensory centres, giving rise to hallucinations; *alcohol*, upon the cerebral centres particularly. The alcoholic poison first produces an increased activity of the muscles, then alternate exaltation and depression, both physical and mental; finally, stupor, relaxation of the muscles and deep sleep. These symptoms are transitory; but let the poisoning process be continued, and true delirium, so well known as "delirium tremens," follows, and at length what is known as "chronic alcoholism;" and while intoxication lasts a few hours, and delirium tremens a few days or weeks, chronic alcoholism spreads its baneful influence over years, unless death prevents the full development of the tragedy. The victim of alcoholic poison is equally enfeebled in body and mind. The nervous system becomes exhausted, the moral sentiments perverted, the will-power broken, and he seems powerless to cease from the fatal habit which has produced the change.

2.—With the *opium-eater* the diseases of the nervous system declare themselves even more rapidly than with the drunkard. Says M. Morel: "Given the period at which a person begins to smoke opium, and it is easy to predicate the time of his death: his days are numbered."

3.—*Tobacco* is one of the most virulent poisons. It soothes the nerves temporarily, only to leave them more enfeebled and irritable.

4.—Even excessive use of *tea* and *coffee* may prove disastrous to the health of the nervous system.

441. *The nervous system may be impaired by want of physical exercise.* Among other agencies that affect the nervous system, none exert a wider influence than bodily exercise. It seems to be required to complete the change which the blood undergoes while passing through the lungs and skin, without which the waste of nerve-element could not be repaired. In persons who are merely sedentary, having little occasion for active thought, this want of exercise is sufficiently mischievous; but when there is great mental activity, the mischief is vastly increased. Thousands of ministers, lawyers, those who sit in the bank and counting-room, shorten their days because of this neglect: especially is this the case in America. The English nobility, notwithstanding their many indulgences, are a long-lived race, and this is doubtless owing to their spending so much time in open-air exercise. (§ 41.)

442. *The nervous system and mental activities may be enfeebled by an unhealthy skin.* If its normal state is impaired by want of cleanliness, by deficient apparel or by a diseased action of the nucleated epithelium through an intimate sympathy in like tissues, the nucleated cells of the nerve-tissue may be seriously affected. (§ 49.)

443. *The nervous system may become impaired by taking too little sleep.* "Sleep knits up the raveled structure" of nervous element, for during sleep organic assimilation is restoring what has been expended in functional energy. A periodical renewal of nervous energy as often as once a day is an institution of Nature. Among the wise arrangements of the Creator, none harmonizes with the wants of the system more perfectly than the alternation of day and night. The amount of sleep necessary depends upon the age, health, natural temperament and occupation of the individual. The more rapid the exhaustion of nervous energy from any cause, the more sleep will be required. The young and the aged need more sleep than the person of middle life, the sick more than the well, those engaged in mental pursuits more than those wearied by manual labor, persons of great sensibility more than the sluggish natures whose normal condition is more

nearly allied to sleep, woman more than man. We may say in general that the time should not be less than from six to eight hours, and most persons require a longer period. The time, however, must be proportioned to the need.

Observation.—Among the more affluent classes the customs of the times are quite incompatible with those habits of sleep which are essential to mental vigor. Where amusements are pursued till late hours night after night, the nervous system greatly suffers, and every department of the mind becomes unhealthy. The man who, eager to become rich, takes time from his sleep for business purposes, draws from his brain capital. The mother— Alas! here we must stop. Mothers are the one class who hardly get any rest till the "blessed Father takes them in his arms and gives his beloved sleep."

444. 3d, Harmonious Action of the Various Mental Powers. That the bodily organs may be directly affected by impressions purely *mental* does not admit of doubt. Of this fact the skillful physician never loses sight, for a hopeful, healthful influence of the mind may be made a remedial agency quite as powerful as that of drugs and plasters.

445. *Regular and systematic mental exercise is essential to the health of nerve-tissue.* Exercise increases the flow of blood to the active part. We have seen this to be the case in the muscle, and that by use it is both enlarged and strengthened. In like manner the nerve-tissue needs exercise; and as the gymnast becomes expert, not by spasmodic muscular efforts, but by accurate, persistent drill, so must the mental athlete gain his power by the regular performance of such exercise as he is able to bear. The gymnast at first feels pain in his muscles, but he has only to persevere, with proper intervals of rest, and what was at first so difficult becomes easy, while power is gained for severer feats. So the person unaccustomed to mental gymnastics feels headache and confusion at first, but frequent repetition will make easy and natural the very thoughts which struggled so painfully into existence, and the nerve-tissue will gain the firmness which increases its capability of action. Under such a course of training the change in the brain-tissue is often so great as to modify perceptibly the form of the head.

Observation.—Says Dr. Ray: "I have no hesitation in saying that of all the means for preserving health there is nothing more sure or better suited to a greater variety of persons than habits of regular and systematic mental occupation of some dignity and worth. In this proposition I would embrace all those kinds of employment which pass under the general name of business, and which, little as we are disposed to recognize the fact, bear the same relation to the health of the mind that food, exercise, etc., do to the health of the body. Work is the condition of our being as active and progressive creatures."

446. *The saddest effects of the absence of stated useful employment are seen among women of easy circumstances.* "It is a poor view of woman's duties and capacities that confines her to a little busy idleness because the chances of fortune have placed her beyond the necessity of earning a living; and they must have but a narrow view of the exigencies of social life who believe that any woman of tolerable health and strength may not find abundant opportunities of that kind of work which affords no other recompense than the consciousness of doing good, and therefore to be done, if done at all, by those who can dispense with every other compensation."

Observation.—A life of idleness and luxurious ease can be no more honorable to one sex than to the other, and we know very well that in a man it creates no claims upon the respect and confidence of the community. The little accomplishments of needlework, so generally diffused, cannot be dignified with the name of work. Many a mind, liberally endowed, from want of mental exertion becomes dwarfed or may end in mental depression, particularly if ill health or deep affliction throws its weight into the scale.

447. *The amount of exercise should be adapted to the health and age of the individual.* If from any cause the nervous system be weakened, an amount of exercise which would be quite harmless to one in health may prove disastrous. The nerve-tissue of children and youth needs the same care as has been shown requisite for other tissues, and overwork that in the adult is followed by fatigue, easily removed by rest, in the child may result in irreparable injury. At this period the tissue is soft and yielding, and when the blood-vessels become long distended by great activity, they may become permanently enlarged and permanent congestion produced.

The present tendency is to treat the mind like a race-horse, goading it on to make a certain round in a given time, and that before the brain-tissue has gained the consolidation requisite for severe exertion. Mary Lyon, with her characteristic wisdom, refused to admit to the Mount Holyoke course of study girls under sixteen years of age, and from her long list of applicants usually selected those not less than eighteen. Let the material organ of the mind be subjected to a systematic, thorough, gymnastic training, taking for it the *necessary time,* and the firm, educated tissue will be fitted for enduring labor in later years; but let it be weakened in *youth,* and it must ever work under a burden, if indeed it work at all. Moderation in mental exertion is also a necessity with the aged, as they have no vitality for recuperation after severe exhaustion.

448. *Intense activity too long continued impairs the strongest brain.* The nerve-cells in a state of rest are neutral in their chemical character, but after severe exercise they become acid. When in this condition it is hazardous to continue the exercise. Sufficient rest should be taken to restore them to their normal condition. Congestion, or an undue accumulation of blood, also attends excessive functional action. The effect of severe congestion in the spinal centres is to produce convulsions; in the sensory centres roaring in the ears, flashes of light before the eyes and various hallucinations; in the ideational centres stagnation of ideas, swimming in the head, and, if long continued, irregular and convulsive action of the cells, causing delirium.

449. *The required rest is often afforded by recreation and amusement.* Important as stated employment unquestionably is to the mental health, amusement or recreation is scarcely less so. Few persons, whatever their mental character or temperament, can safely dispense with these altogether. Even the most commanding intellects sometimes seek the recreation which their exhausting labors make necessary in forms of amusement which, to those who feel the necessity less, seem to be frivolous and puerile.

Observation 1.—To those whose life is one of severe toil and harassing care, amusements constitute almost the only practicable means for repairing the constant waste of the nervous energy. Especially is this want felt by women in the humbler walks of life, whose daily round of care and toil not only draws more largely than that of the stronger sex on the physical and mental energies, but is lightened by none of that relief which is afforded by a greater variety of duties and more frequent periods of rest.

2.—The brain, when severely taxed, is often rested by some kind of mental exercise, which, without being fatiguing, requires just enough effort to impart interest. Hence, a change from mathematics to the languages, or from these to music, poetry or painting, will give the needed relaxation.

450. *To maintain the highest mental vigor each faculty of the mind should receive its due share of cultivation.* Our various faculties were not bestowed at random, to be used as inclination may prompt, but each has its appointed place in the mental economy. Each bears some relation to every other, making one harmonious whole. One must form habits of attention, accustom the mind to continuous thought, cultivate the reasoning powers and beget a taste for exact knowledge, if he would be in any measure equal to the intellectual effort essential to true success in every calling of life. He must, however, also call into action the creative power of the mind, the *imagination*, to give vividness to his conception, to add force to his reasoning, and to light up the whole horizon of his thought. Its exercise must not be indulged to an extent incompatible with the claims of the other faculties. It must not be allowed to fashion with unbridled power our principles and motives, our aims and ends. Give it, however, the purest material to work with, and, within proper bounds, no faculty is of more real service or more worthy of our regard. Especially is it of value in presenting to the mind an ideal of excellence, a standard of attainment, practicable and desirable, but loftier than anything we have yet reached.

451. The *æsthetic* faculty, the *love of the beautiful*, should not be allowed to remain inactive. Its importance is recognized only as we understand its value. An object is beautiful to us just in proportion to our power to discover through the

material form the *thought* of which this form is but the expression, for beauty is but the spirit looking out through the visible, the material.

452. Man has also a *moral* faculty, the power of discriminating between right and wrong, which is quickly followed by the feeling of obligation to do the right and avoid the wrong. Upon the right use of these faculties depend the happiness and the destiny of man. The power of an approving conscience over the human mind, and consequently over the health of the Nervous System, cannot be over-estimated, while on the other hand the torments of an accusing conscience not only "cut the sinews of the soul's inherent strength," but snap one by one the gossamer filaments of the brittle thread of life.

453. Concerning the hygienic influence of a HARMONIOUS DEVELOPMENT OF THE MENTAL POWERS, Dr. Ray says: "A partial cultivation of the mental faculties is incompatible not only with the highest order of thought, but with the highest degree of health and efficiency. The result of professional experience fairly warrants the statement that in persons of a high grade of intellectual endowment and cultivation, other things being equal, the force of moral shocks is more easily broken, tedious and harassing exercise of particular powers more safely borne, than in those of an opposite direction, and disease, when it comes, is more readily controlled and cured. The kind of management which consists in awakening a new order of emotion, in exciting new trains of thought, in turning attention to some new matter of study or speculation, must be far less efficacious, because less applicable, in one whose mind has always had a limited range, than in one of larger resources and capacities. In endeavoring to restore the disordered mind of the clodhopper who has scarcely an idea beyond that of his manual employment, the great difficulty is to find some available point from which conservative influences may be projected. He dislikes reading, he never learned amusements, he feels no interest in the affairs of the world, and, unless the circumstances allow of some kind of

bodily labor, his mind must remain in a state of solitary isolation, brooding over its morbid fancies, and utterly incompetent to initiate any recuperative movement."

§ **47.** Comparative Neurology.—*The Comparison of the Nervous System of other Mammals with that of Man—Of Birds—Of Reptiles—Of Amphibians—Of Fishes. Peculiar Arrangement of some Fishes. The Arrangement of the Nervous System of Mollusca—Of Radiata.*

454. Animals, whatever their structure may be, have certain relations with the external world; all nourish themselves; the lowest type, as the sponge, nourishes itself, as far as the result to itself is concerned, as does man. All Vertebrates do not possess a vertebral column, but all do possess something analogous to the spinal cord—a "notochord." The nervous system of Vertebrates is highly developed, and is composed of nerves, ganglions and a cerebro-spinal axis, or brain and spinal cord. The latter are not represented in Invertebrates.

Fig. 156.

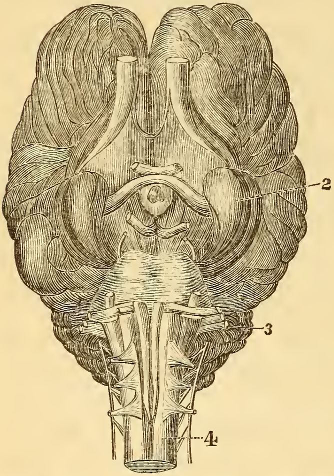


Fig. 156 (*Owen*). Base of Brain of a Horse.—1, Cerebrum. 2, Optic ganglion. 3, Cerebellum. 4, Medulla Oblongata and Spinal Cord.

455. In other *Mammals*, the relative size of the cerebrum and cerebellum, except in the lowest order, as the Duck-mole, is about the same as in man; but the sulci of the brain of other mammals are less developed than in man, and certain ganglions are comparatively larger. The

brain of all mammals is formed on the same plan; in man alone the posterior lobe of the cerebrum overlaps the cerebellum. In the Horse, Ox, etc., the olfactory, optic and auditory ganglions are large, and the senses of smell, sight and hearing are acute. In some animals, as the Mole, where vision is feeble, and in others where smell or hearing is obtuse, the ganglionic bulbs are very small and the nerves very delicate.

456. In *Birds* the hemispheres are not united by a corpus callosum; the cerebellum is proportionately larger than the medulla oblongata, and the comparative weight of the brain

FIG. 157.

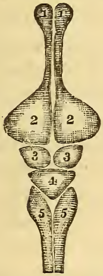


FIG. 158.

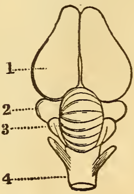


FIG. 159.

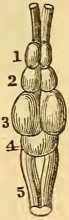


FIG. 157. BRAIN OF AN ALLIGATOR.—1, Olfactory ganglia. 2, Cerebrum. 3, Optic ganglia. 4, Cerebellum. 5, Medulla Oblongata and Spinal Cord.

FIG. 158. BRAIN OF A BIRD.—1, Cerebrum. 2, Optic ganglion. 3, Cerebellum. 4, Medulla Oblongata.

FIG. 159. BRAIN OF A FISH.—1, Olfactory ganglia 2, Cerebrum. 3. Optic ganglia. 4, Cerebellum. 5, Medulla Oblongata and Spinal Cord.

to the body is less than in mammals. The optic ganglions in birds are large, which is particularly apparent in the Eagle, Vulture and Buzzard. In these, vision is not only far-reaching, but acute, and the same is true, to a certain extent, of smell and hearing.

457. The brain of *Reptiles* is smooth and without convolutions. The hemispheres are hollow, and there is no striated body. The cerebellum sends no prolongations across the

medulla oblongata, as in mammals. The optic and olfactory ganglions are, in general, large. Hearing is less complete than in mammals.

458. In *Amphibians* the nervous system is but slightly developed. The cerebrum is small; the cerebellum is scarcely visible.

459. The brain of the *Fish* is small; it does not fill the whole cranial cavity, there being found within it a spongy, fatty mass. The investment and protection of some of the organs of special sense are modified, as seen in the eye of the deep-sea shark, where the sclerotic tunic of the eye is bony, in order to protect this organ from the great pressure of the water. Perhaps the most wonderful arrangement is found in the electric fishes, as the common Torpedo, and the Electric Eel of South America. In the latter, the electric organs are composed of membranous tubes closely packed like honeycomb and arranged along the back and tail. The peculiar electric property depends on the posterior lobe of the brain.

Fig. 160.

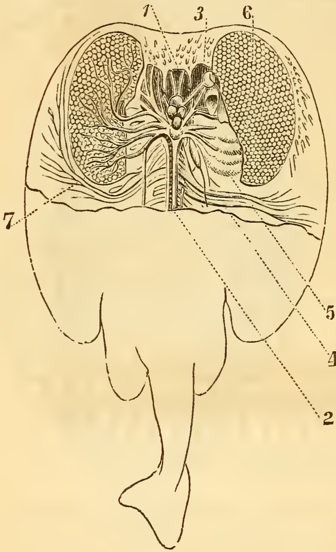


Fig. 160. Electric Organs of Torpedo.—1, Brain. 2 Spinal cord. 3, Eye and optic nerve. 4, Spinal nerve. 5, Branchiæ. 6, Electrical organ. 7, Pneumogastric nerve.

460. In the *Annulosa*, in general, each segment or ring has

a pair of nervous ganglions. The ganglions of the nerves of special sensation, as of sight and hearing, of motion, of respiration and nutrition, are larger than those of general sensation.

Fig. 161.

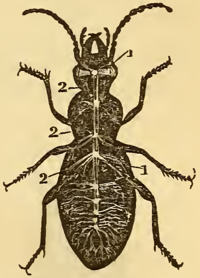


Fig. 161. Nervous System of the Beetle.—1, 1, Central ganglia. 2, 2, 2, Nerves that connect the ganglia.

461. The nervous system of insects is composed principally of a double series of ganglions united by longitudinal cords. The brain ganglions are large, and give origin to the optic nerves and the antennæ.

In the nervous system of the centipede, whose general structure is similar to that of other articulates, the ganglions are arranged in pairs of nearly equal size, except the ganglion that answers to the brain, which is larger, along the ventral surface of the alimentary canal. Each pair is connected with the preceding, with the integument or skin, and with the muscles of its own segment, by sensitive and motor filaments of nerves.

Fig. 162.

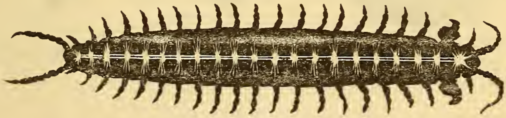


Fig. 162. Diagram of a Centipede.

462. In *Mollusca* are found the ganglia and commissure arrangement, with nerves sensitive and motor, afferent and efferent, and on a plan corresponding to the body. The structure of the organs of sense is less complete than in vertebrate animals. Some mollusca possess only the sense of touch and taste; a great number have eyes, whose structure varies; none have yet been found possessing a special organ for smell. (Fig. 163.)

463. In the RADIATA the star-fish manifests one of the simplest forms of the nervous system. It consists of a central mass, with five arms radiating from it. In the centre is the mouth, and beneath it the stomach or gastric cavity, which sends prolongations to each limb. The nervous system consists of five similar ganglions situated in the central portion at the base of the arms. These ganglions are connected by commissures, and each sends off nerve-filaments to the corresponding limbs. (Fig. 164.)

FIG. 163.

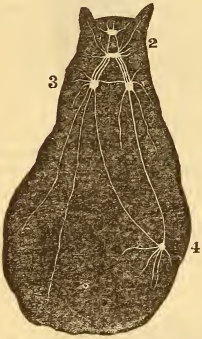


FIG. 164.

FIG. 163. DIAGRAM OF THE TYPE OF A MOLLUSCA.—1, Œsophagal ganglia. 2, Cerebral ganglia. 3, Pedal of locomotive ganglia. 4, Respiratory ganglia.

FIG. 164. DIAGRAM OF A RADIATA—THE STAR-FISH.

Observation 1.—We have seen that in all grades of the animal kingdom the cell-structure obtains, but in the lowest forms of animal life nerve does not exist. The stimulus which the little creature receives from without would seem to produce some change in the molecular relations of its almost homogeneous substance, and these insensible movements collectively to amount to the sensible movement which it makes.

2.—With the differentiation of tissue and increasing complexity of organization which are met with as we ascend in the animal kingdom the nervous tissue appears, but at first under a very simple form. Its simplest type may be represented as two fibres that are connected by a nerve-cell; the fibres are apparently simple conductors, and might be

aptly compared to the conducting wires of a telegraph, while the cell, being the centre in which nerve-force is generated, may be compared to the telegraphic apparatus. In it the effect which the stimulus of the afferent nerve excites is transmitted along the efferent nerve, and therein is displayed the simplest form of that *reflex* action which plays so large a part in animal life.

3.—The relations of the animal kingdom afford a striking evidence of divine unity, bound together in the closest harmony, and the work of Him who was the Beginning and will be the End.

ANALYTIC EXAMINATION.

Chapter XI.—Nervous System.

§ **43.** *Anatomy of the Nervous System.*—392. What two formal characters does Nervous Tissue present? Give the arrangement and names of each. 393. How are the Ganglia, Nerves and Commissures arranged? What is included in each system? 394. Describe the Spinal Cord. What is the Medulla Oblongata? To what is this enlargement due? What may be seen in each of the lateral halves of the Medulla Oblongata? What forms the Decussation of the Anterior Pyramid? How is the Fourth Ventricle formed? 395. Where is the Cerebellum? How is the Pons Varolii formed? Describe the Inferior Peduncles of the Cerebellum. What are the Peduncles of the Cerebrum? Give the course of these bundles. How are these ganglia connected with the Spinal Cord? Of what does the Quadrigeminal Body consist? 396. What is said of the connections of all the above-mentioned ganglia? 397. How are the hemispheres of the Cerebrum united? How are the ventricles formed? 398. What is the relation of the Cerebrum to the other parts? How many lobes has each hemisphere? How does the surface appear? 399. How do the convolutions in the two hemispheres compare? What is a remarkable fact respecting these convolutions? 400. What is said of the Cerebellum? 401. What do the brain and spinal cord constitute? 402. Into what classes are the cerebro-spinal nerves divided? How are the motor and sensory tracts formed? 403. Distinguish between cranial and spinal nerves. 404. How are the cranial nerves arranged? 405. How many pairs of spinal nerves? How do they differ from the cranial as to their origin? Compare the sensitive sort with the motor. 406. What are the divisions of the spinal nerves? What are plexuses? Name them and give their formation. 407. Describe the Sympathetic System. 408. What is a peculiarity of the sympathetic nerves?

§ **44.** *Histology of the Nervous System.*—409. Name the elements of nervous tissue. 410. Describe the nerve-cells. What is a Ganglion? Where are the nerve-cells found? 411. Of what do the White Fibres consist? 412. Where are the nerve-filaments distributed? What is said of their individuality? How are they arranged? What their mode of termination? 413. Where are the Tubular Fibres found? What of their size? 414. What are the Gray Fibres? 415. Name the membranes of the Cerebro-spinal System. Describe the Dura Mater, Pia Mater and Arachnoid Membrane. 416. Give a further description of the Dura Mater. 417. What is the Ependyma?

§ **45.** *Physiology of the Nervous System.*—418. How is the Nervous System related to the compound nature of man? Observation. 419. What influence has this system on the different organs? 420. Speak of the connection between the Nervous Centres and the motor and sensitive fibres. Illustrate Reflex action. 421. Classify the Nervous Centres. Observation. 422. What is the function of the Sympathetic Centres? 423. What is said of their connections? 424. Name and illustrate the different kinds of reflex action. Observation. 425. What is the office of the white substance of the spinal cord?

What that of the gray? Observations. 426. Describe the Sensational Centres. Show that these centres have an independent reflex action. Can they acquire reflex action? Observations. 427. How are these centres excited to activity? 428. What power have the Ideational Centres? Observations. 429. What is the first way in which the independent reflex action in these centres is manifested? What the second? Third? Fourth? 430. Of what are these centres the seat? 431. What relation is there between the centre of idea and that of volition? 432. What is the highest energy of which these centres are capable? 433. Upon what does the power of the Will depend? 434. What relations to the Emotions does the Will sustain? Observations.

§ **46.** *Hygiene of the Nervous System.*—435. Why is a knowledge of the laws of the hygiene of this system important? 436. What agencies affect the health of this system? Name the requirements of its health and vigor. 437. What in addition to the features of parents do children inherit? May acquired habits be transmitted? Illustrations. 438. State the second requirement of health and vigor. 439. Speak of the evil of breathing impure air. 440. What are the results of improper diet? Observations. 441. What will a want of physical exercise produce? 442. By what may the nervous system be enfeebled? 443. Speak of the benefits of sleep and the amount needed. Observation. 444. Name the third requirement of health. 445. Why is mental exercise essential? Observation. 446. Where are seen the saddest effects of an absence of stated employment? Observation. 447. To what should the amount of exercise be adapted? What is the present tendency in education? What training is essential? 448. State the effect of too long continued activity. 449. Give the influence of recreation and amusement. Observations. 450. What is essential to the highest mental vigor? What is said of the use of the imagination? 451. What attention is it important to pay to the æsthetic faculty? 452. What is the moral faculty? Upon what depend the happiness and destiny of man? 453. Give Dr. Ray's remarks concerning the hygienic influence of a Harmonious Development of the Mental Powers.

§ **47.** *Comparative Neurology.*—454. What is said of the Nervous System in Vertebrates and Invertebrates? 455. Compare the Nervous System in other Mammals with that in man. 456. Describe that in Birds. 457. In Reptiles. 458. In Amphibians. 459. Describe the brain of the Fish. What is said of the Electric Eel? 460. Describe the Nervous System in Annulosa. 461. In Insects. In the Centipede. 462. Speak of the nervous system in Mollusca. 463. Describe the nervous system in Radiata. Observations.

UNIFIC REVIEW.

[Compare 392–408 with 454–463.]

Compare the Nervous System in man with that in the lower orders of animals.

[Compare 409 and 410 with 9, 26, 27 and 30–32.]

Give the composition of nervous tissue. Describe its first element.

[Compare 411–414 with 28 and 29.]

Describe the White and Gray Fibres. Where are they found?

[Compare 415–417 with 17, 18, 30 and 31–33.]

What tissues and what membranes belong to the Cerebro-Spinal System? What names do they assume there?

[Compare 420–426 and 428 with 394, 395, 398, 402, 407 and 408.]

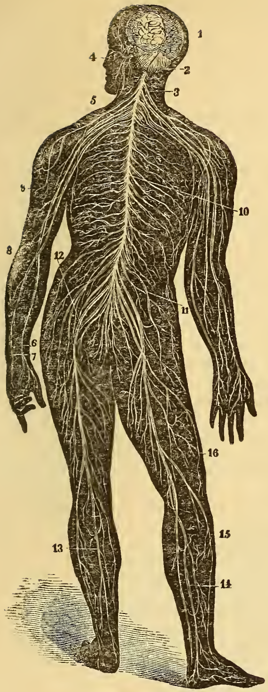
Name the Nervous Centres. Give their functions. Speak of the Sympathetic System.

[Compare 438–440 with 247, 266 and 372–374.]

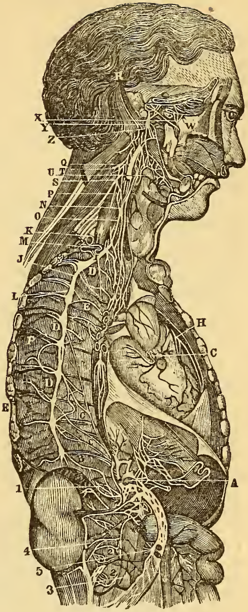
What is essential to the health of the Nervous System? What is said of food and air in this connection?

[Compare 441 with 183–196.]

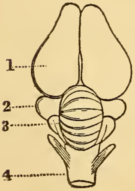
What can you say of the influence of physical exercise on the health of the Nervous System?



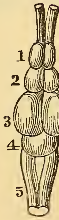
(See Fig. 151.



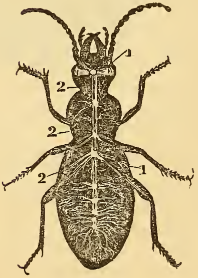
(See Fig. 152.)



(See Fig. 158.)



(See Fig. 159.)



(See Fig. 161.)

SYNTHETIC TOPICAL REVIEW.

Chap. XI. *Nervous System.*

§ 43. *Anatomy of.*

Nervous Tissue. Forms,
" " Arrangement,
Ganglia, Nerves and Commissures,
Spinal Cord,
Medulla Oblongata,
Cerebellum, Peduncles,
Cerebrum, "
Corpora Striata,
Optici Thalami,
Corpora Quadrigesima,
Corpus Callosum,
Ventricles,
Cerebrum Hemispheres,
Convolutions,
Cerebro-Spinal Nerves,
Cranial and Spinal Nerves,
Sympathetic System.

§ 44. *Histology of.*

Nervous Tissue, Composition,
Nerve-Cells,
Nerve-Fibres,
Membranes.

§ 45. *Physiology of.*

Nervous System. Its relation to this nature,
" " Man's compound nature,
" " Its rank,
Nervous Centres. Function,
" " Classes,
" " Arrangement,
Organic Centres. Function,
" " Connection,
" " Modes of reflex action,
" " Marked peculiarity,
Reflex Centres. Function,
" " Acquired action,
" " Importance of acquired action,
Sensational Centres. Character and action,
" " How excited to activity
Ideational Centres. Function,
Different persons have different ideas,
Ideational Centres. Independent reflex action,
" " Emotional character,
" " Volitional,
Relation of the Emotions to the Will,
Influence of the body for good or evil,
Language of the muscles.

§ 46. *Hygiene of.*

Agencies affecting the health,
Natural heritage,
Impure Air, influence of
Improper Diet, "
Poisons, "
Physical Exercise, want of
Sleep, "
Mental Exercise,
Employment,
Amount of exercise,
Intense Activity,
Recreation,
Each faculty to be educated,
The Æsthetic faculty,
The Moral "

§ 47. *Comparative Neurology.*

Vertebrates and Invertebrates, Nervous System,
Mammals, "
Birds, "
Reptiles, "
Amphibians, "
Fishes, "
Annulosa, "
Insects, "
Mollusca, "
Radiata, "
Lower forms of Life, "

CHAPTER XII.

THE ORGANS OF SPECIAL SENSE.

UNDER this head are classed the *Tongue*, the *Nose*, the *Eye*, the *Ear* and the *Tactile* portions of the Nervous System.

§ **48.** ANATOMY OF THE ORGANS OF SPECIAL SENSE.—*The Organ of Taste—Of Smell. The Coats of the Eye. The Humors of the Eye. The Muscles of the Eye. The Protecting Organs. Classification of the Organs of Hearing. The External Ear. The Labyrinth. The Internal Ear. The Organs of Touch. Two Layers of Skin. The Epidermis. The Dermis. The Hairs. The Sebaceous Glands. The Perspiratory Glands. The Nails.*

464. The organ of the SENSE OF TASTE is the mucous membrane which covers the *Tongue*, especially the back part

FIG. 165.

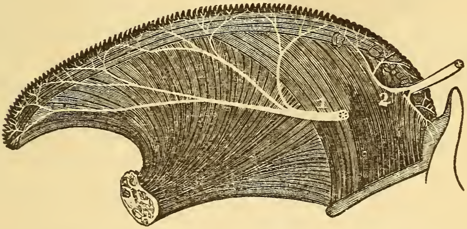


FIG. 165 (*Dalton*). DIAGRAM OF THE TONGUE, with its sensitive nerves and papillæ. 1, Lingual branch of fifth pair. 2, Glosso-pharyngeal nerve.

of this organ, and the palate. Upon the upper surface of the tongue the mucous membrane has various little eminences, called *papillæ*, resembling the villi of the intestines. The principal of these are of a composite character, and present three varieties—the *Circumvallate*, the *Fungiform* and the

Conical. The CIRCUMVALLATE papillæ are shaped like the letter V with the point turned downward, and are surrounded by an annular wall-like elevation, whence their name. They are about a dozen in number, and are found upon the posterior part of the tongue. The FUNGIFORM papillæ are broad at the free extremity and narrow at the base, having something of the mushroom shape, whence their name. They are more numerous than the circumvallate, and are scattered over the surface of the tongue, but are especially numerous at and near the tip. The CONICAL papillæ are smaller and more numerous than the others, and are found in the intervals between them, arranged in rows diverging from the median line of the tongue. All the above-described papillæ and the spaces between are covered with *simple* papillæ, conical in form. From those surrounding the conical papillæ, the squamose epithelium rises in hair-like appendages, which give a brush-like arrangement, admirably adapted to the imbibition of liquids to be tasted. These hair-like appendages give the velvety character to the surface of the tongue, and upon them the furred condition of this organ depends. Minute blood-vessels and nerves pass up into these

FIG. 166.

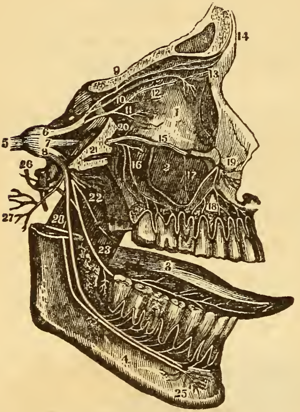


FIG. 166. THE DISTRIBUTION OF THE FIFTH PAIR OF NERVES.—1, The orbit for the eye. 2, The upper jaw. 3, The tongue. 4, The lower jaw. 5, The fifth pair of nerves. 6, The first branch of this nerve that passes to the eye. 9, 10, 11, 12, 13, 14, Divisions of this branch. 7, The second branch of the fifth pair of nerves is distributed to the teeth of the upper jaw. 15, 16, 17, 18, 19, 20, Divisions of this branch. 8, The third branch of the fifth pair that passes to the tongue and teeth of the lower jaw. 23, The division of this branch that passes to the tongue, called the gustatory. 24, The division that is distributed to the teeth of the lower jaw.

papillæ, thus giving a large extent of sensitive surface. (Fig. 166.)

Nervous filaments are received from the fifth, ninth and twelfth pairs of nerves. The branch of the fifth, called the *Gust'a-to-ry,* is the nerve of taste and ordinary sensibility; the twelfth, the *Hypo-glossal,* of voluntary motion. By means of the ninth, the *Glosso-pharyngeal,* the tongue is brought into association with the fauces, œsophagus and larynx. It is of obvious importance that these parts should act in concert; and this is effected by the distribution of this nerve. (Fig. 166, §§ 49, 50.)

465. The organ of the SENSE OF SMELL is a part of the delicate mucous membrane lining the *Nasal Passages.* These passages extend from the opening of the nostrils in front to the pharynx behind; they are high, vaulted and narrow, and separated from each other by a partition partly bony and partly cartilaginous. This double cavity is separated from the mouth by a bony floor (the hard palate), which is continued backward to the root of the tongue by a fleshy curtain, called the soft palate. In ordinary positions of the mouth, this palate and the root of the tongue effect a closure between the mouth and the pharynx. Each of the outer walls of the nasal chamber has three thin, bony processes called *turbinated* bones, arranged one above another, like shelves. One of these processes is called *cribriform;* upon it rest the olfactory lobes, which send numerous filaments through the perforations to the mucous membrane of the two upper turbinated bones,

FIG. 167.

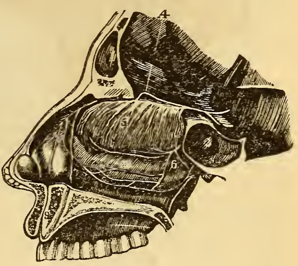


FIG. 167. A SIDE VIEW OF THE PASSAGE OF THE NOSTRILS, AND THE DISTRIBUTION OF THE OLFACTORY NERVE.—4, The olfactory nerve. 5, The fine divisions of this nerve on the membrane of the nose. 6, A branch of the fifth pair of nerves.

affording the special sense of smell; the membrane of the lower bone receives a branch from the fifth nerve, which is endowed with common sensibility only; the odor of cologne, for example, is distinguished by the olfactory nerve, and the pungency by the branch of the fifth nerve. (§§ 49, 50, Fig. 167.)

466. The chief organ of the SENSE OF SIGHT is the *Eye.* The globe of the eye, or eyeball, is composed of three concentric envelopes, viz., the *Sclerot'ica* with the *Cornea* in front, the *Cho'roidea* with the *Iris* in front, and the *Ret'ina,* which is internal. These make up most of the solid part of the eyeball, which is a hollow sphere filled with three fluid or semi-fluid substances—the *Aqueous Humor,* the *Crystalline Lens* and the *Vitreous Humor.* (Fig. 168.)

FIG. 168.

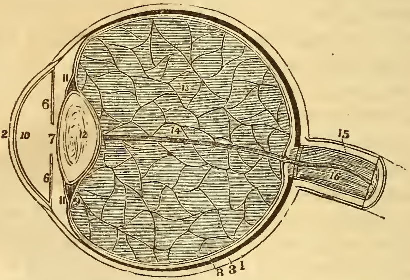


FIG. 168. A SECTION OF THE GLOBE OF THE EYE.—1, The sclerotic coat. 2, The cornea. (This connects with the sclerotic coat by a beveled edge.) 3, The choroid coat. 6, 6, The iris. 7, The pupil. 8, The retina. 10, 11, 11, Chambers of the eye that contain the aqueous humor. 12, The crystalline lens. 13, The vitreous humor. 15, The optic nerve. 16, The central artery of the eye.

The SCLEROTICA or Sclerotic Coat invests the globe of the eye, excepting the part covered with the cornea in front. It is composed of white fibrous tissue arranged in many layers, which cross each other at right angles and form a tunic of great strength. It is white, glassy and opaque, and is commonly called "the white of the eye." It has few blood-vessels, and seems destitute of nerves. (Fig. 168.)

The CHOROIDEA or Second Coat of the eye has some fibrous tissue like the sclerotica, but is chiefly composed of blood-vessels and pigment-cells. These cells give the coat an intense black color on the inside, but externally it is brown. It lines the sclerotica, and is connected with it by a delicate areolar tissue. It is perforated behind for the passage of the optic nerve, and terminates in front in the *cil'iary* ligament, in the anterior part of which the iris is inserted. (Fig. 168.)

The IRIS occupies the opening of the choroidea in front, forms a partition between the anterior and the posterior chambers of the eye, and is pierced by a circular opening which is called the *Pupil.* It is free except at its peripheal attachments, and floats freely in the aqueous humor. The posterior surface of the iris or ŭvea is thickly covered with pigment, but the anterior surface gives the *color of the eye,* so remarkably and beautifully varied in different individuals, and presenting numerous blended tints of black, brown, blue and gray. The iris is generally regarded as a modification of muscular tissue. It has two layers of fibres—one layer of radiating fibres, converging from the circumference to the centre, the other of circular fibres. (Fig. 169.)

FIG. 169.

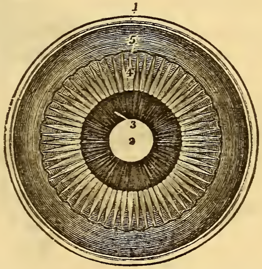


FIG. 169. A VIEW OF THE ANTERIOR SEGMENT OF A TRANSVERSE SECTION OF THE GLOBE OF THE EYE, SEEN FROM WITHIN.—1, The divided edge of the three coats—sclerotica, choroidea and retina. 2, The pupil. 3, The iris, the surface presented to view in this section being the uvea. 4, The ciliary processes. 5, The scalloped anterior border of the retina.

The CILIARY PROCESSES consist of a number of minute triangular folds, formed apparently by the plaiting of the internal layer of the choroid coat toward its front part. Their bases are toward the pupil, and the free portion rests against the circumference of the crystalline lens. These processes are covered with pigment-cells. (Fig. 169.)

The RETINA is the inner coat of the eye formed by the expansion of the optic nerve upon the inner side of the choroid coat, but not extending so far forward. It ends at a short distance from the ciliary ligament, in a jagged edge, from which an exceedingly fine membrane extends to the ciliary processes. Its inner surface is bounded by an exceedingly delicate membrane which separates it from the vitreous humor. (Figs. 168, 169.)

467. Of the three humors or liquid substances of the eye, the AQUEOUS or watery is situated in the anterior portion of the organ, behind the cornea. It is an albuminous fluid, with an alkaline reaction and liquid like water. The iris is placed vertically in the fluid, the space between it and the cornea being the *anterior chamber* of the eye, and that between the iris and crystalline lens behind, the *posterior chamber*. The two chambers are lined by a membrane secreting the aqueous humor. (Fig. 168.)

FIG. 170.

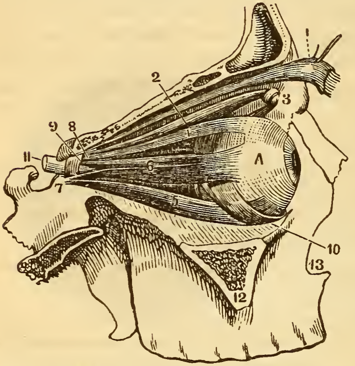


FIG. 170. MUSCLES OF THE EYE.—1, The palpebral elevator muscle. 2, The superior oblique. 3, The pulley through which the tendon of insertion plays. 4, Superior straight muscle. 5, Inferior straight muscle. 6, External straight muscle. 7, 8, Its two points of origin. 9, Interval through which pass the oculo-motor and abducent nerves. 10, Inferior oblique muscle. 11, Optic nervé. 12, Cut surface of the malar bone. 13, The nasal orifice. A, The eyeball.

The CRYSTALLINE humor or lens is situated immediately behind the pupil, and is surrounded by the ciliary processes. It is invested by a transparent elastic membrane called the capsule of the lens. The humor is more convex on the pos-

terior than on the anterior surface. It is imbedded in the anterior part of the vitreous humor, from which it is separated by a thin membrane. The lens consists of thin layers like the coats of an onion. The external layer is soft, but each successive one increases in firmness.

Observation.—When the crystalline lens or its investing membrane is changed in structure, preventing the rays of light from passing to the retina, the affection is called a *cataract.*

468. The VITREOUS HUMOR forms the principal bulk of the globe of the eye. It is an albuminous fluid resembling the aqueous humor, but is more dense, and if once discharged by disease or accident, it is irrecoverably lost, while the aqueous humor may be lost and afterward restored. This humor is enclosed in a delicate membrane called the *hy'aloid,* which sends processes into the interior of the globe of the eye, forming the cells in which the humor is retained.

469. The MUSCLES of the eye are six in number. They are attached at one extremity to the orbit behind the eye; at the other extremity they are inserted by broad, thin tendons to the sclerotic coat, near the junction of the cornea. The white, pearly appearance of the eye is caused by these tendons. (Fig. 170.)

Observation.—If the external muscle is too short, the eye is turned out, producing the " wall eye;" if the internal muscle is contracted, the eye is turned inward toward the nose, and is called a "cross eye."

470. The PROTECTING ORGANS of the eye are the *Orbits, Eyebrows, Eyelids* and *Lach'rymal Apparatus.*

The ORBITS are deep, bony sockets in which the globes of the eye are placed. The bottom of each orbit has a large perforation, giving passage to the optic nerve. These cavities are lined with a thick cushion of fat.

The EYEBROWS, forming the upper part of the boundary of the orbits, are two tegumentary prominences covered with coarse hair.

The EYELIDS are two movable curtains, having a delicate skin on the outside, muscular fibres beneath, and a narrow cartilage on their edges, which tends to preserve the shape

of the lid. Internally, they are lined by a smooth mucous membrane, which is reflected on the front of the eye upon the sclerotica. This membrane is called the *Conjuncti'va.*

On the internal surface of the cartilage there are found several small glands, which have the appearance of parallel strings of pearls. They open by minute apertures upon the edges of the lids.

The edges of the eyelids are furnished with a triple row of hairs, called eyelashes, which curve upward from the upper lid, and downward from the lower. (Fig. 171.)

Observation.—When the conjunctiva is inflamed, it sometimes deposits a whitish material called *lymph,* which accounts for the films, opacities and white spots seen upon the eye after the inflammation has subsided. Not unfrequently granulations form on the inside of the lids, which should receive surgical treatment before the inflammation extends over the eyeball.

The LACHRYMAL APPARATUS which secretes the tears consists of the *Lachrymal Gland* with its ducts, *Lachrymal Canals* and the *Nasal Duct.*

FIG. 171.

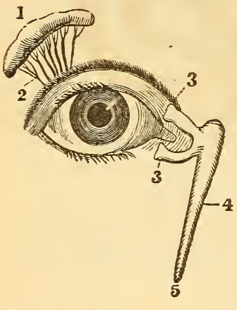


FIG. 171. VIEW OF LACHRYMAL GLAND AND NASAL DUCT.—1, The lachrymal gland. 2, Ducts leading from the lachrymal gland to the upper eyelid. 3, 3, The puncta lachrymalia. 4, The nasal sac. 5, The termination of the nasal duct.

The LACHRYMAL GLAND is situated at the outer and upper angle of the orbit, occupying a depression in the orbital plate of the frontal bone. Ten or twelve small ducts pass from this gland and open upon the upper eyelid, where they pour upon the conjunctiva the lachrymal fluid or tears.

The LACHRYMAL CANALS commence at the free borders of each eyelid, near the internal angle of the eye, by two minute orifices, called "punc'ta lach'rymalia" (tear points). Each of these ducts

communicates with the sac at the upper part of the nasal duct. (Fig. 171.)

The Nasal Duct is a short canal about three quarters of an inch in length, directed downward and backward to the nose, where it terminates by an expanded orifice. The tears secreted by the lachrymal gland are conveyed to the eye by the small ducts before described. They are then taken up by the puncta lachrymalia and carried by the lachrymal canals into the lachrymal sac, from which they are passed to the nasal cavities by the nasal duct. (Fig. 171, §§ 47, 48.)

Fig. 172.

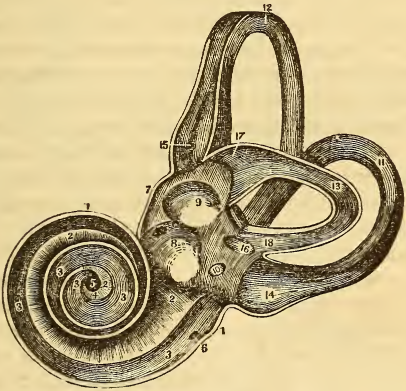


Fig. 172. A View of the Labyrinth Laid Open.—1, 1, Cochlea. 2, 2, 3, 3, 3, Two canals that wind two and a half turns around a hollow axis (5). 7, Central portion of the labyrinth (vestibule). 8, Fenestra rotunda. 9, Fenestra ovalis. 11, 12, 13, 14, 15, 16, 17, 18, The semicircular canals. Highly magnified.

471. The Sense of Hearing does not strictly belong to one organ, but to several, which are grouped into three divisions—the *External Ear*, the *Tym'panum** and the *Labyrinth* or *Internal Ear*.

472. The Labyrinth is so called from its remarkable

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* Gr., *túmpanon*, a drum.

and varied configuration. It is divided into three portions—the *Vestibule*, the *Semicircular Canals* and the *Coch'lea.**

473. The VESTIBULE is a small and somewhat triangular cavity about the size of a grain of wheat. It is placed almost vertically in the centre of the labyrinth, and is a kind of entrance-chamber or ante-room to the semicircular canals behind the cochlea in front. (Fig. 172.)

474. The SEMICIRCULAR CANALS are three curved passages, describing more than half a circle, and are about the twentieth of an inch in diameter. Two of them open into the vestibule at both extremities, and the third at one extremity. Both the vestibule and the canals contain a transparent fluid like lymph, and in this fluid, without touching the walls of the cavity, floats a membranous labyrinth corresponding in form to the bony one, but considerably smaller. It is a sheath or bag enlarged at the vestibule, and sending out prolongations into the semicircular canals on the one side and the cochlea on the other. It is filled with a lymph-like fluid of greater consistency than that in which it floats. The auditory nerve is distributed in the walls of this membranous labyrinth, and nervous filaments connect it with its bony counterpart. (Fig. 172.)

475. In front of the vestibule is the COCHLEA, so called from its resemblance to a snail-shell. It consists of a bony canal which winds around a hollow axis nearly three times, gradually decreasing in diameter, and thus forming a spiral cone. The interior of the canal is divided into two passages by a membranous partition, upon which the remaining parts of the auditory nerve ramify. The passages are filled with lymph, and communicate with each other at the apex of the cone and at the base; one opens into the vestibule, called the *Fenes'tra Ovalis;* this small oval-shaped perforation is closed by a thin fibrous membrane, which prevents the escape of the fluid from the vestibule, and through it the sonorous vibrations pass to the labyrinth;

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* Gr., *kochlos*, to twist.

the other, the *Fenestra Rotunda*, opens into the *Tympanum.* (Fig. 172.)

476. The Tympanum or middle ear is an irregular bony cavity, larger than the vestibule and just outside of it. It is separated from the external ear by a thin, semi-transparent membrane of an oval shape. This is very closely fitted into a groove between the tympanum and the auditory canal. The tympanum is often called the *Drum* of the ear, and very

Fig. 173.

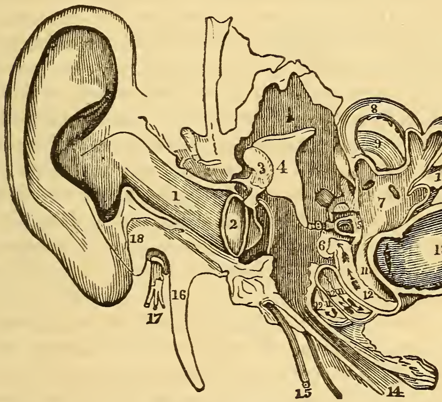

Fig. 173. A View of all the Parts of the Ear.—1, The canal that leads to the internal ear. 2, The membrana tympani. 3, 4, 5, The bones of the ear. 7, The central part of the labyrinth (vestibule). 8, 9, 10, The semi-circular canals. 11, 11, 11, 12, 12, 12, The channels of the cochlea. 13, The auditory nerve. 14, The opening from the middle ear or tympanum to the throat (Eustachian tube).

appropriately, for the membrane of the tympanum is in contact with the atmosphere, whose sonorous vibrations beat upon it much like drumsticks upon the head of a drum. There are several openings into the tympanum, of which the largest is called the *Eustachian tube*, from the name of the first anatomist who described it. It is a trumpet-shaped canal, somewhat over an inch and a half long, extending from the fore

part of the tympanum obliquely inward, forward and downward to the pharynx. The tube is lined with a ciliated epithelium continuous with that of the pharynx and tympanum. In the tympanic cavity are three bones or *ossicles*, the smallest in the body, weighing only a few grains. From their resemblance to the articles, they have been named the *Mallet*, *Anvil* (attached to this bone is a little tubercle or *orbicular* bone, which is sometimes regarded as a separate ossicle) and *Stirrup*. The Mallet and Anvil articulate by a hinge joint, the Anvil and Stirrup by a ball-and-socket joint. (Fig. 173.)

477. The External Ear lies outside the membrane of the tympanum. It is composed of the auditory canal and the part which projects from the head. The canal or *External Mea'tus Audito'rius* is partly bony and partly cartilaginous, about one inch in length and narrower in the middle than at the extremities. Short, firm hairs are stretched across the tube, preventing the ingress of foreign bodies. Beneath the thin cuticle are small follicles which secrete the *Ceru'men* or wax. The part of the external ear outside the cavity has numerous prominences and ridges.

478. The Sense of Touch has its seat in the *Skin*. This membrane covers the whole exterior of the body, and at the margins of the apertures is directly continuous with the mucous membrane, which last is an integument of greater delicacy, but has substantially the same composition, viz., a deep fibrous, sanguine, sensitive layer, a basement membrane and an epithelium, or superficial, insensible and bloodless layer. Thus the whole body, externally and internally, has a complete epithelial investment.

479. The skin consists of two layers; a superficial one, destitute of nerves and blood-vessels, is called the *Epidermis*,* and a deeper layer, abundantly supplied with nerves, and highly vascular, called the *Dermis* or *Cutis Vera* (true skin). (Fig. 175.)

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* Gr., *epi*, upon, and *derma*, skin.

480. The EPIDERMIS consists of two layers, different in many respects, one called the *Cuticle*, the other the *Soft Epidermis* (and named by some physiologists the Rete Mucosum). The epidermis holds the same relation to the dermis that the epithelium does to the deeper layer of the mucous membrane. It varies in thickness from the thin, delicate membrane upon the internal flexions of the joints to the thickened covering of the soles of the feet. This variation is perceptible in infants before exercise can have had any influence. (Fig. 175.)

FIG. 174.

FIG. 174. FRAGMENT OF DANDRUFF FROM THE HEAD.—1, Portion of dandruff consisting of non-nucleated cells. 2, Several fragments, consisting of nucleated cells. 3, Isolated cells, some with and some without nuclei. 4, A cell more highly magnified, exhibiting granular contents and a nuclei.

During life the EPIDERMIS is constantly undergoing loss, throwing off the superficial epidermoid scales, which are constantly renewed by fresh cells originating on the surface of the true skin. These gradually undergo transformation from the spherical to the flattened shape as they approach the surface of the cuticle. (Fig. 175.)

The SOFT EPIDERMIC layer is the seat of the color of the skin. The difference between the blonde and brunette, the European and the African, lies only in the deep, newly-formed layers of the epidermis. In the whitest skin the cells of the epidermis always contain a slight amount of the pigmentary tint, which disappears from the cells as this soft layer is transformed into the cuticle.

481. The CUTICLE is a translucent, horn-like membrane. Its deeper surface is continuous with the soft epidermic layer, from which it is constantly renewed. Its free surface is incessantly wearing away or shed in small flakes, constituting scurf or dandruff.

482. The DERMIS or True Skin presents two very different surfaces, of which the external is called the *Papillary* layer,

the internal the *Corium*.* The dermis is made up of interlacing bundles of white areolar tissue, mixed with yellow elastic fibres. These are so interwoven as to constitute a firm, strong and flexible web. In the superficial part the web is so close as to resemble felt cloth. In the deepest layers the network is loose, and encloses the hair-follicles with their sebaceous glands and small masses of fat. (Fig. 175.)

Fig. 175.

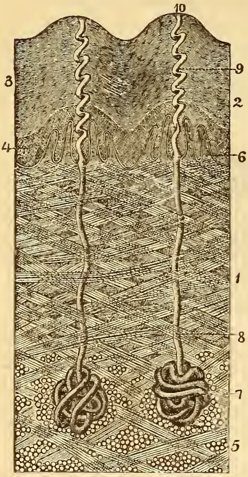


Fig. 175. Vertical Section of the Skin of the Forefinger across Two of the Ridges of the Surface. Highly magnified. 1, Dermis, composed of an intertexture of bundles of fibrous tissue. 2, Epidermis. 3, Its cuticle. 4, Its soft layer. 5, Subcutaneous connective and adipose tissue. 6, Tactile papillæ. 7, Sweat glands. 8, Duct. 9, Spiral passage from the latter through the epidermis. 10, Termination of the passage on the summit of ridge.

483. The Papillary or outer layer of the dermis is provided with a multitude of little conical-shaped projections. These are prolongations of the upper compact tissue of the corium into the newly-formed layer of the epidermis. They vary in number and degree of development in different parts of the body. The papillæ are very numerous on the palm of the hand and on the free border of the lips.

484. The Dermis is abundantly supplied with *blood-vessels*, *lymphatics* and *nerves*. Its general surface is covered with a close capillary network, from which looped vessels project and enter the papillæ. The lymphatics also form a close network on the surface. The nerves pass upward from the subcutaneous areolar tissue, and form, as they approach the surface, minute plexuses,

* Gr., *chorion*, skin.

from which the nerve-fibres are given off. Some of these fibres are lost in the compact tissue of the dermis; others end, perhaps, in loops; and many pass into certain of the papillæ (for it is said that some of these do not receive nerve-fibres). In the papillæ these fibres end in loops, or, as in the fingers, the sole of the foot, and perhaps on the red margin of the lips and the point of the tongue, they appear to terminate in small oval, condensed bodies, called *tactile corpuscles,* situated in the centre of the papillæ. In any case, it is supposed that the nerve-fibre turns back to rejoin some nerve-cell in the nervous centres. The network of nerves imbedded in the upper porous layer of the true skin is derived from nerves which take their winding course through the fat, distended openings of the *Corium.* (Fig. 175.)

FIG. 176.

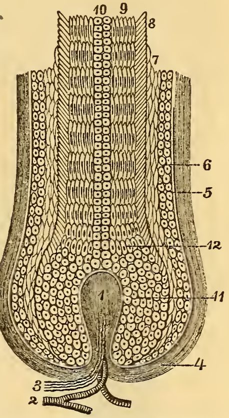


FIG. 176. DIAGRAM OF STRUCTURE OF THE ROOT OF A HAIR WITHIN ITS FOLLICLE.—1, Hair papilla. 2, Capillary vessel. 3, Nerve-fibres. 4, Fibrous wall of the hair-follicle. 5, Basement membrane. 6, Soft epidermic lining of the follicle. 7, Its elastic cuticular layer. 8, Cuticle of the hair. 9, Cortical substance. 10, Medullary substance. 11, Bulb of the hair, composed of soft polyhedral cells. 12, Transition of the latter into the cortical substance, medullary substance and cuticle of the hair.

485. The minute depressions from which the hairs of the skin emerge are called the *Hair-follicles* or sacs. They are buried in the corium. At the bottom of the follicle is a more or less elevated portion of the dermis, often forming a distinct papilla, which is destitute of cuticle. The root of the hair is composed of soft, pale and somewhat compressed nucleated cells; it is adherent to the lining of the follicle or *root-sheath.* When a hair is plucked out, the sheath adheres to it, but the vascular papilla at the bottom of the follicle remains, and a new hair is generated upon it. If the papilla is destroyed, no new hair

can be formed. All these papillæ, except those of the finest hairs, probably receive nervous fibrils. The part of the hair projecting above the surface is called the *shaft*. The shaft is usually cylindrical, but sometimes flattened. It consists of an outer part, called the *cortex*, composed of a single layer of imbricated scales whose edges are directed toward the point of the hair. Beneath the cortex is the so-called fibrous part of the hair, which constitutes its bulk, and consists of fusiform cells clustered into flattened fibres, running longitudinally and intermixed with pigment granules. Lastly, the very deepest cells, occupying the centre of the shaft and constituting the pith, are not elongated, but polyhedral and loosely connected together, and containing chiefly pigment or fat granules. (Fig. 176.)

Fig. 177.

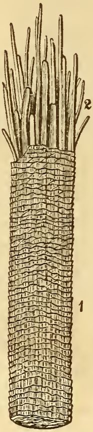


Fig. 177. Portion of a Hair from the Outer Part of the Thigh. Magnified. 1, Shaft of the hair covered with transverse markings indicating the projecting edges of the cuticular, imbricated scales. 2, Cortical substance at the end of the hair, broken up into coarse fibres, as the result of friction of the clothing.

486. Each hair-follicle receives, in nearly all cases, the ducts of two *Sebaceous* or *Oil-Glands*, which are situated in the dermis. They are found only where hairs exist. Each gland is a flask-shaped body, composed of from five to twenty little sacs, clustered around and leading into a common duct. These glands are lined by a fine epithelium, and the unctuous secretion first anoints the hair-bulb, and then oozes out upon the neighboring surface of the cuticle. The sebaceous glands are of considerable size. (Figs. 176, 178.)

487. Immediately beneath the skin, over the whole surface of the body, there are a multitude of little glandular bodies, called *Perspiratory* or *Sweat Glands*. Each gland consists of

a minute, cylindrical, spiral duct, which passes inward through the epidermis, and terminates in a globular coil, in the deeper meshes of the true skin. The opening of the duct upon the cuticle is called the "pore." This aperture is oblique in direction, and possesses all the advantages of a valvular opening, preventing the ingress of foreign injurious substances to the interior of the duct or gland. It is estimated that six thousand glands exist on every square inch of surface, and the combined length of the glandular tubing in the body is between two and three miles. These glands, coming in con-

Fig. 178.

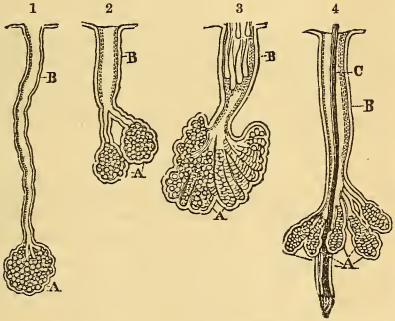


Fig. 178. Oil-Glands and Ducts, magnified thirty-eight diameters. 1, A, Oil-gland from the scalp; B, Its duct. 2, A, Two glands from the skin of the nose; B, Common duct. 3, A, Oil-gland from the nose; B, The duct filled with the peculiar animalculæ of the oily substance; the heads are directed inward. 4, A, Cluster of oil-glands around the shaft of the hair (C); B, Ducts.

tact with the capillary blood-vessels, receive a watery fluid (the perspiration) from the blood. The formation of perspiration is constant, but usually evaporation takes place as fast as it reaches the surface. This is called the "insensible transpiration" of the skin. (Figs. 178, 175.)

488. The Nails are horny appendages of the skin, and correspond with the hoofs and claws of animals. They are flexible, translucent plates continuous with the epidermis,

and rest on the depressed surface of the dermis, called the matrix or bed. By maceration or severe scalding, even in life, the nail is detached with the epidermis.

The horny layer of the nail answers to the cuticle; it is composed of numerous layers of flattened, nucleated cells or scales, while the soft layer corresponds with the deep parts of the epidermis, and is made up of delicate polyhedral, nucleated cells.

Fig. 179.

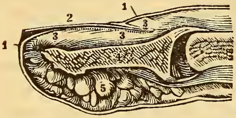


Fig. 179. A Section of the End of the Finger and Nail.—4, Section of the last bone of the finger. 5, Fat, forming the cushion at the end of the finger. 2, The nail. 1, 1, The cuticle continued under and around the root of the nail at 3, 3, 3.

The nails increase in length by the constant addition of cells at the root; they grow in thickness by the formation of cells on the under surface. This double development explains why nails are thickest at their most convex portion. (Fig. 179.)

§ **49.** Physiology of the Organs of Special Sense.—*Primary Use of the Sense of Taste—Of Smell. Some of the Laws of Light. The Adaptation of the Eye to the Laws of Light. Cause of Short-sightedness—Of Long-sightedness—Defect remedied. Functions of the different Coats of the Eye. The Accessory Parts of the Eye. Hearing. Functions of the External Ear—Auditory Canal—Eustachian Tube—Cochlea and Semi-circular Canals. Sounds reach the Fluid of the Labyrinth by two Paths. Special Organ of the Sense of Touch. Functions of the Skin. Use of the Epidermis—Of the Cuticle—Of Cutaneous Papillæ. Vessels of the Corium. Function of the Oil-glands. Uses of Perspiration.*

489. The primary use of the Sense of Taste is to guide animals in the selection of food, that noxious articles may not be introduced into the stomach. In man this sense has been so abused and perverted by the introduction of condiments and the endless admixture of different articles of food, that the natural action seems to have been almost entirely superseded by acquired taste. This sense becomes very acute by cultivation, as may be seen in those persons whose business it

is to judge of the qualities of certain articles by the taste, as tasters of wine, tea, etc. The acuteness of taste, however, varies in different persons according to the sapid bodies themselves. (§§ 48, 50.)

Observation.—Hard, insoluble substances have no taste; hence, whatever is tasted must be in the fluid form or in solution in some other liquid. For this reason the various movements of the tongue, to facilitate *actual contact* of substances to be tasted with the lining membrane of the mouth and fauces, show that we should eat slowly, dissolve the food and mingle it with the saliva, as not only a source of physical enjoyment but essential to health.

490. In man the SENSE OF SMELL is one of inferior importance. It furnishes the mind with but few ideas, and these are mostly subservient to his physical well-being. This sense leads us to avoid disagreeable odors or putrescent food, and, when acute, to escape the injurious effects of many vapors which endanger health. (§§ 48, 49.)

Observation.—The sense of smell is possessed in greater perfection by some of the lower animals than by man. Odors are perceived by them that are imperceptible to us. A dog will follow his master's footsteps through crowded streets, distinguishing their odor from different travelers. Some animals when disturbed emit a disagreeable odor, which serves as a means of defence.

491. The STRUCTURE OF THE EYE is beautifully adapted to the laws of light, a few of which it is necessary for us to notice.

When light passes through a medium of unvarying density, the rays are in straight lines, but when it passes from a medium of one density into another of different density, they are refracted or bent from a straight course unless striking the medium perpendicularly, when they are unchanged. When light passes from one medium to another having a convex or concave surface instead of a flat surface, a great degree of refraction is produced, and the greater the curvature, the greater will be the amount of refraction. (§§ 48, 50.)

Illustration 1.—Fit a convex lens in an opening of the shutter of a darkened room; the rays of light will cross each other in the lens, and an inverted image of any object outside, as a tree or house, will be

reflected upon a screen placed in the room at a certain distance in front of the lens. The exact point where the image is most distinct is called the *focus of the lens,* and the distance from the lens to the image the *focal distance.* Now, in the eye the pigment of the choroid coat gives the darkened room, the retina the screen, the pupil is the opening in the shutter, and the three humors are the curved lenses. The rays of light from any object cross each other, and an inverted image is formed on the retina.

492. The shape of the cornea and aqueous humors is convexo-concave, the vitreous humor is concavo-convex, while the crystalline humor or lens is convexo-convex. It may at first seem that only one lens is necessary, but light is composed of three primary colors which are not equally refracted by the same lens; hence, there would be upon the edges of any single lens prismatic colors, which would interfere with the distinctness of the image. This is obviated by the adaptation of the curvatures of the lenses to the different colors.

2.—Suppose our object outside the darkened room to be at that distance from the lens which will give a distinct image upon the screen; now, if the object approach the lens, the image will be indistinct unless a more convex lens be substituted for the first, or the distance between the lens and screen be increased. If the object recede, the image will be indistinct unless a less convex lens be substituted for the first, or the distance be lessened between the lens and screen.

493. *By a very nice adjustment the eye is able to change the convexity of its lenses,* and also to vary the focal distances, thereby adapting it to a wide range of vision. This is accomplished by the ciliary ligament and the muscular fibres connected with the ciliary processes, which change the curvature of the crystalline lens and the cornea by compression at the circumference, and at the same time throw the lens forward, increasing the distance between it and the retina. The iris also aids in adapting the eye to different distances. It contracts when viewing a near object and dilates when viewing one more remote.

Observation.—When the cornea or crystalline lens is too convex or the latter is too far from the retina, *short-sightedness* is produced, and the defect is measurably remedied by the use of concave glasses; when

there is too little convexity, *long-sightedness* is the result, and convex glasses should be used. In old age, the humors being deficient in quantity, cause the flattening of the convex parts, hence the need of convex glasses. In the selection of glasses the lens for each eye should be chosen separately, as the foci of the two eyes do not usually exactly correspond; therefore a lens that will suit one eye may strain the other.

494. *The Sclerotic Coat* gives form to the eye, and serves for the attachment of the muscles which move the eye in various directions. The movements of the two eyeballs are always simultaneous and harmonious, but sometimes not symmetrical. The function of the pigment of the choroid coat is to absorb all the luminous rays not necessary for vision.

Illustration.—"If the sclerotic and choroid coats be carefully dissected off from the posterior part of the eye of an ox or any other large quadruped, leaving only the retina, and the eye so prepared be placed in a hole in a window-shutter, in a darkened room, with the cornea on the outside, all the illuminated objects of the external scene will be beautifully depicted, in an inverted position, on the retina. Few spectacles are more calculated to raise our admiration than this delicate picture which Nature has, with such exquisite art and with the finest touches of her pencil, spread over the smooth canvas of the expansion of the optic nerve—a picture which, though scarcely occupying a space of half an inch in diameter, contains the delineation of a boundless scene of earth and sky, full of all kinds of objects, some at rest and others in motion, yet all accurately represented as to their forms, colors and position, and followed in all their changes without the least interference, irregularity or confusion."

495. *The Accessory Parts of the Eye* are of two kinds; the one designed to protect the eyeball, the other to move it and give the required direction to fulfill its office. To enable the eye to move in all directions without friction, it is placed on a cushion of fat which lines the bony orbit, thus protecting the globe on all sides except in front; here are the *Eyelids*, which by their alternate movement of depression and elevation spread over the front of the eyeball a watery secretion, by which its surface is constantly bathed, and its brilliancy and transparency kept unimpaired.

By the contraction of a small ring-like muscle (the *Orbicularis*) the eyelids quickly draw together, and as they instantly

separate, the secretion from the lachrymal gland is diffused over the conjunctiva. During life this muscle is ever active and watchful for the safety of the eye. When cinders or dust get under the eyelids, it irritates the conjunctiva, and the movements of winking are very rapid. A viscid fluid is spread along the margin of the lid, which prevents the tears running over the eyelid.

The *Cilia* or *Eyelashes* so interlace that protection is given the eye from light substances floating in the air. The *Eyebrows* assist in shading the eyes when exposed to strong light, and they lend expression to some emotions of the mind.

496. HEARING is that function by which we obtain a knowledge of the vibratory motions of bodies, which constitute sounds. Independent of the sense of hearing, sound, as sound, has no existence in nature.

497. The *External Ear* collects the waves of sound and reflects them on the membrane of the tympanum; this membrane facilitates their transmission to the chain of bones in the tympanum, to the walls of the cavity and to the air it contains; from the stirrup to the oval window; from this membrane the vibrations are communicated to the fluid of the labyrinth, until finally they are received by the expansion of the auditory nerve, by which the sensation is communicated to the brain.

498. The *function of the Auditory Canal* is to receive and conduct sonorous vibrations to the membrane of the tympanum. This membrane is admirably adapted for the reception of atmospheric sound-waves. In hearing, the air in the tympanic cavity plays an important part; the design of the *Eustachian tube* is evidently to allow of equal atmospheric pressure upon both sides of the membrana tympani. The complicated communications of the internal ear contain the highly important parts of the organ of hearing. The *Vestibule* is the part essential to the simplest exercise of this sense. The *Cochlea* and *Semicircular* canals, or rather their contained membranous canals, receive vibrations through the mixed membranous and bony tympanic apparatus. It is asserted by

some physiologists that sound is communicated through the cranial bones; the transmission, however, through the solid bones of the head, if it exists, is effected with difficulty.

499. By this sense, therefore, we distinguish the quality, intensity, pitch, duration and direction of sonorous impulses. The delicacy with which these distinctions are appreciated varies in different individuals. The complication and finish of the auditory apparatus, and the perfection and delicacy of its action, are second only to those of vision.

500. The Sense of Touch, though common to all parts of the *Skin* and adjoining mucous membranes, has for its special organ *the hand.* It is most admirably adapted to its office, by reason of the number, size, arrangement, structure and abundant nervous supply of its papillæ.

Observation.—In some animals, the tongue, in others, feelers, tentacula or a prolongation of the nose are the instruments of touch.

501. The functions of the Skin are threefold: 1st, As a *Protecting* membrane; 2d, As a *Medium* for the distribution of the tactile nerve-filaments; and 3d, As an *Eliminating* organ. Investing as it does the entire surface of the body, following all its curves and prominences, arranged in layers differing in function, structure and vitality, the skin becomes an envelope of harmonious unity in appointment and end.

502. The uses of the *Epidermis* are various. It serves to cover and protect the delicate sensitive parts beneath it; to prevent the too rapid escape of heat; and to restrain the evaporation of the fluids of the skin and its appendages, at the same time that it furnishes a medium through which these secretions can reach the surface of the body.

Observation.—The cuticle is constantly destroyed and replaced, as is proved by the disappearance from the skin of such stains as those produced by nitrate of silver, or the scales thrown off after some acute diseases, as scarlatina. The restoration of the cuticle is observed after the process of vesication by blisters, and in consequence of burns and scalds. By these means large patches of cuticle are removed; but they are renewed in short time, under favorable circumstances. The pigmentary substance is also capable of rapid reproduction.

503. In the *Corium* or internal layer of the skin resides vitality. Here the arteries of the skin penetrate from beneath, and end in a capillary network; the veins emerging from the skin are more numerous and much larger than the arteries. The skin is abundantly supplied with nerves, but their mode of termination has not been accurately ascertained.

504. The surface of the skin possesses the power of *absorbing* both liquids and vapors. The principal, if not sole, agents of this function on the surface of the body are the cutaneous *Lymphatic* vessels, which are active in proportion to the tenuity or absence of the cuticle. To a slight extent the skin is a respiratory membrane in man, giving off carbonic gas and actually absorbing oxygen.

505. The *Sebaceous matter* from the *Oil-glands* anoints the hairs with oil in their progress of growth from the skin, and also imbues the cuticle, by which it is rendered repellent of water. The oiliness of the surface of the skin, occasioned by this material, permits the ready adhesion of dust and dirt, and necessitates the use of soap for the easy removal of its excess. This oily product often becomes inspissated and distends the glands, most frequently in the face, and especially on the nose, and at the mouths of the ducts it becomes mixed with dust. When pressed out it assumes the spiral form of the duct; hence it is commonly taken for a worm. In the healthiest individuals the sebaceous matter contains a curious parasite, called the "pimple mite."

506. The uses of the *Perspiration* or sweat are twofold: 1st, To free the system of a certain quantity of water; and 2d, To eliminate from the body certain special products of chemical changes.

The quantity of perspiration exhaled by different parts of the body differs widely. Its general quantity is influenced both by intrinsic and extrinsic conditions; thus, it is augmented by increased vascularity of the skin, by a higher temperature of the body, by a quicker circulation, and therefore by exercise and effort generally. Perspiration may also

be induced by additional covering of the body, and also by peculiar conditions of the nervous system.

507. Of the external conditions which modify the quantity of perspiration, the *condition of the atmosphere* is most important. Thus, in warm air the activity of the cutaneous circulation is increased, which increases the perspiration, whilst cold air has the opposite effect; again, dry air increases the perspiration, whilst damp air diminishes it. Simple warmth acts by increasing the vascular action through the skin, whilst dryness operates by maintaining a constant evaporation from this membrane; on the other hand, cold diminishes the vascularity of the skin, and dampness of the air impedes evaporation. The combination of moisture with heat, however, increases the exhalation by the skin, which then appears in large drops. Large quantities of warm drinks also increase perspiration.

Observation.—The skin is said to regulate the quantity of fluid given off by the kidneys and the quantity of fluid left in reserve in the blood and soft tissues generally, but the kidneys should rather be regarded as the true regulators. Observation shows that in cold weather the skin exhales less and the kidneys excrete more fluid, while in warm weather the skin eliminates more and the kidneys less.

508. The use of the non-vascular and insensible outgrowth of the epidermis, the *Hair*, is protection; and the function of the *Nails* is not only protection, but support to the yielding softness of the flesh at the finger-tips. When they reach exactly to the extremities of the fingers, they then fulfill the intention for which they were made, by enabling the fingers to hold both small and hard substances, and to tear and peel off skins of vegetables or animals. They are called into action where nicety of execution is required in art.

§ **50.** Hygiene of the Organs of Special Sense.—*Perversion of the Sense of Taste—Of Smell. How the Eye should be Used. Causes of Amaurosis. The Effect of Continued Oblique Position of the Eye—Viewing Objects at Different Distances. Bathing the Eye—Removal of Dust. Causes of Defective Hearing. Parts Essential to Hearing. Clothing. Kind of Material for Clothing. Class of Persons that need more Clothing. Cleanliness of Clothing. Bathing—Modes of Bathing—Time for Baths—General Rules for Bathing—Water a Curative Agent. Air Beneficial to the Skin. Effect of Light on the Skin.*

509. The *Sense of Taste* becomes perverted by the immoderate use of stimulants and condiments. These indulgences lessen the sensibility of the nerve. In children this sense is usually acute, and their preference is for food of the mildest character.

Observation.—This sense is varied more than any other by the refinements of social life; thus, the Indian's like or dislike regarding particular articles of food generally extends to every individual of the tribe, but among civilized men no two persons are alike in all their tastes.

510. The *Sense of Smell* may become impaired by being frequently and powerfully stimulated by pungent articles, as "smelling salts;" also catarrh, or any influence that thickens the mucous membrane or renders it dry, diminishes the sensibility of the nerve of smell. Hence, the sense becomes very obtuse to persons addicted to the pernicious habit of "snuff-taking."

511. *The Eye is a delicate organ, requiring care to preserve it in health;* like other organs of the body, it should be exercised and then rested. The observance of this rule is particularly needful to those whose eyes are predisposed to inflammation. If the eye be used too long at one time, it becomes wearied and the power of vision diminished. On the contrary, if not called into exercise, its functions are enfeebled or permanently impaired.

512. *Sudden transitions of light should be avoided.* The iris enlarges or contracts according to the degree of light, but the change is not instantaneous. Hence the imperfect vision in passing from a strong to a dim light; an overwhelming sensation is experienced when passing from a dimly-lighted apart-

ment to one brilliantly illuminated. A common cause of *Amaurosis,* or paralysis of the retina, is using the eye for a long time in a very intense light.

513. *Long-continued oblique position of the eye should be avoided,* or it may produce an unnatural contraction of the muscles called into action, producing squinting or strabismus.

Observation.—The vision of a cross eye is always defective, as only one eye is used in viewing the object toward which the attention is directed. The defect is remedied by a surgical operation. Children should not be allowed to imitate the "cross eye," as what is intended to be but temporary may become permanent.

514. *The eye of the child should be trained to view objects at different distances.* The ciliary muscles are as capable of education as any others, and may be made to act very efficiently in adapting the lenses of the eye to view near or remote objects. Care on the part of the instructor and parent regarding the distance from the eye at which the child should hold his book or work would save many cases of defective vision.

Observation 1.—*Bathing the eye in tepid or cold water is beneficial,* provided the eye be gently wiped and usually toward the inner angle; also to remove the secretion from the lachrymal gland that sometimes collects at this angle, as it contains saline matter.

2.—Particles of dust or cinders should be removed from the eye by means of soft linen or silk. If the substance is concealed beneath the upper lid, take a smooth rod, like a knitting needle, place it over the upper lid in contact with and just under the edge of the orbit; hold it firmly by means of the lashes, turn the lid gently back over the needle, and remove the intrusive substance. If unsuccessful, too many attempts should not be made, as inflammation may be induced, but consult a surgeon immediately.

515. The *Sense of Hearing,* like the other senses, is capable of great improvement. By cultivation, the blind are able to judge with great accuracy of the distance of bodies in motion, and even of the height of buildings. The Indian will distinguish sounds inaudible to the untrained ear.

516. *Hearing may be impaired* by the destruction of the membrane of the tympanum. The obstruction of the Eusta-

chian tube is not unfrequently the cause of defective hearing. By its closure, the vibratory effect of the air within the tympanum is diminished in the same manner as in the closure of the side of a drum. Enlarged tonsils, inflammation of the fauces and nasal passages, often attend and follow colds and attacks of scarlet fever, etc. For such deafness, remedial means should be directed by a skillful physician.

Observation.—The *nostrums* for the cure of deafness are usually of an oily character, and may be useful in cases of defective hearing caused by an accumulation of wax in the external canal of the ear; but a few drops of any animal oil will serve the purpose as efficiently.

517. In hearing, the integrity of the drum of the ear is not absolutely essential for the due performance of the function. The loss of the small bones does not necessarily cause deafness unless the stirrup is diseased; but if the auditory nerve or membranous vestibule becomes diseased, there is no remedial agent for the loss of hearing.

518. The *Hygiene of the Skin*, the chief organ of the Sense of Touch, holds important relation to the general health of the body. To maintain its healthy action in every part, attention must be given to *Clothing*, *Bathing*, *Light* and *Air*.

519. CLOTHING is chiefly useful in preventing the escape of too much heat from the body, and in protecting the body from exposure to the evil effects of a varying temperature of the atmosphere. In selecting and applying clothing, the following should be observed:

520. *The material for clothing should be a bad conductor of heat.* As air is a non-conductor, material should be chosen which is capable of retaining much air in its meshes, and as moisture increases the conducting power, the material should not be such as will absorb or retain moisture.

Observation.—Furs retain much air in their meshes and absorb scarcely any moisture, and consequently are well adapted to those subject to the great exposures of very cold climates. *Woolen cloth,* next to furs and eider down, retains the most air and absorbs the least moisture; hence it is a good article of apparel for all persons, unless too irritable to an over-sensitive skin. In that case the flannel may be lined with cotton, or *silk* may be substituted. When of sufficient body or thick-

ness, silk is a good article for inner clothing, excepting when it produces too much disturbance of the electricity of the system. Next to these articles, *cotton* is well adapted for garments worn next the skin. *Linen* should never be worn by persons in any way enfeebled, even in warm weather or in hot climates. It is a good conductor of heat and readily absorbs moisture; hence, with such covering, the body is surrounded by a layer of moisture instead of air.

521. *The clothing should be both porous and loosely fitted.* The necessity of porous clothing is seen in the wearing of India-rubber overshoes. In a short time the hose and under-boot become damp from retained perspiration. The residual matter thus left in contact with the skin is reconveyed into the system by absorption, causing headache and other diseases. Unimpeded transpiration, and a layer of air secured by loose clothing, enable the skin to imbibe oxygen, which gives it tone and vigor.

Observation.—As the design of additional clothing is to enclose a series of strata of warm air, we should, in going from a warm room into cold air, put on our extra covering some time previous to going out, that the layers of air which we carry with us may be warmed by the heat of the room, and not borrowed from the heat of the body.

522. *The clothing must be suited to the state of the atmosphere and to the condition of the individual.* Sudden changes of temperature should be regarded; but it is usually unsafe to make changes from thick to thin clothing, excepting in the morning, when the vital powers are in full play. The evening usually demands an extra garment, as the atmosphere is more cool and damp, and we have also less vital energy than in the early part of the day.

Observation.—Many a young lady has laid the foundation of a fatal disease by exchanging the thick dress, warm hose and shoes for the flimsy fabric, thin hose and shoes which are considered suitable for the ball-room or party. All sudden changes of this kind are attended with hazard, which is proportionate to the weakness or exhaustion of the system when the change is made.

523. *The child and the aged person require more clothing than the vigorous person of middle age.* Judging from observation, we should infer that children needed less clothing

than adults. The exposure to which the vain and thoughtless mother subjects her child very frequently lays the foundation for future disease. Those who have outlived the energies of adult life also need special care regarding a proper amount of clothing.

Observation.—The system of "hardening" children, of which we sometimes hear, is as inhuman as it is unprofitable. To make the child robust and active, he must have nutritious food at stated hours, free exercise in the open air, and be guarded from the cold by *proper apparel.*

524. *When a vital organ is diseased, more clothing is needed.* In consumption, dyspepsia, and even headache, the skin usually is pale and the extremities cold, because less heat is generated. Persons suffering from these complaints need more clothing than those with healthy organs.

525. *Persons of active habits need less clothing than those of sedentary employment.* Exercise increases the circulation of the blood, consequently the vital activities become more energetic, and more heat is produced. We need less clothing when walking than when riding.

526. *The clothing should be kept clean.* Some portion of the transpired fluids of the body must necessarily be absorbed by the clothing; hence, warmth, cleanliness and health require that it should be frequently changed and thoroughly washed. Under-garments worn through the day should not be worn through the night, nor the reverse. When taken from the body, such garments should not be hung in the closet or put into the drawer, but exposed to a current of fresh air.

The covering of beds should be thoroughly aired every morning, and frequently renewed.

527. *Damp clothing is injurious.* All articles from the laundry should be well aired before being worn. When the clothing is wet by accident or exposure, it should be changed immediately, unless the person is exercising so vigorously as to prevent the slightest chill. When the exercise ceases, the body should be rubbed with a dry crash towel till a thorough reaction takes place.

Beds and bedding that have not been used for some weeks become damp, and should be dried before use. A hostess cannot be guilty of a more inhospitable act than that of sending her guest to her fine guest-chamber, to occupy a bed which has been long unused.

528. Bathing is indispensable to sound health as well as to cleanliness. The skin soon becomes covered with a mixture of perspirable matter, oil and dust, which, if allowed to remain, interferes with the action of the skin as an excretory organ. This increases the action of the lungs, kidneys, liver, etc., which take upon themselves the excretory work which the skin fails to perform. By overwork they soon become diseased, and if it is continued, the result will be consumption and other diseases of the vital organs. Again, obstruction of the pores will prevent respiration through the skin, and deprive the blood of one source of its oxygen and one outlet of its carbonic acid.

529. *Bathing gives tone and vigor to the internal organs.* When cool water is applied to the body, the skin instantly shrinks and the whole of its tissue contracts. This contraction diminishes the capacity of the blood-vessels, and a portion of the blood is thrown upon the internal organs. The nervous system is stimulated, and communicates its stimulus to the whole system. This causes a more energetic action of the heart and blood-vessels, and a consequent rush of blood back to the skin. This is the state termed *reaction*, the first object and purpose of every form of bathing. By this reaction the internal organs are relieved, respiration is lightened, the heart is made to beat calm and free, the tone of the muscular system is increased, the appetite is sharpened, the mind more clear and strong, and the whole system seems to possess new power. Regularity in bathing is necessary to produce permanently good effects.

Observation 1.—The simplest modes of bathing are by means of the sponge or the shallow baths. The body may be quickly sponged over, wiped dry and followed by friction. The water may be warm or cold. If cold, the bath should be taken in the early part of the day, and

followed by exercise. If exercise cannot be taken, the individual should rest under covering. The warm bath should usually be taken just before retiring. If taken at other hours, it should be followed by rest from half an hour to one hour under proper covering.

2.—The shallow bath, in which the body is partly immersed in water, is very pleasant and safe, provided the bather exercises in it by vigorous rubbing and does not remain too long. For a cold bath it is not often safe to exceed five minutes, and with delicate persons the time should rarely exceed two or three minutes. A bath is considered cold when below 75°; temperate, from 75° to 85°; tepid, from 85° to 95°. This and every other form of bath should be followed by thorough friction with a coarse towel or flesh-brush.

530. *The frequency of bathing must depend upon the condition and occupation of the individual.* Daily bathing may be practiced with profit by most persons, but to the studious and sedentary it is in most cases absolutely indispensable.

531. *The hour for ablution is of importance.* It should neither immediately precede nor follow a meal. The same is true of severe mental and muscular exercise. The bath is less beneficial in the afternoon than the forenoon. The best time for cold baths is two or three hours after breakfast. The system is then at "flood-tide," while from that time till the retiring hour the tide is ebbing; hence, the worst time for a cold bath is at bed-time. For those who cannot choose their time, the hour of rising will answer very well—that is, for many persons, especially if they become accustomed to the use of water by beginning at another and a better hour. If the mind and body are brightened by the early bath, and an exhilaration follows, the bath is beneficial; if, on the contrary, languor follows, and the skin looks blue or too pale, it is injurious. That the bath is to be followed by exercise must not be forgotten.

532. *In diseases of the skin, and many chronic ailments of the internal organs, bathing is a remedial measure of great power.* In disease which has baffled the skill of physicians depending wholly upon internal remedies, the effect of a systematic course of baths is often surprising. Like other curative means, the baths should be directed by those who

thoroughly understand the use of water as a remedial agency. Matters of diet, exercise, etc., require adaptation to the treatment of the particular case. Those who desire the *full benefit* of these means must avail themselves of the appliances of a well-conducted hygienic establishment.

Observation 1.—A few simple rules must be observed in bathing. The face and head should be wet in cold water before the bath. Cool baths should not be taken when the person is chilly, perspiring or greatly fatigued. All general baths should be taken briskly, the skin well rubbed and quickly dried, followed by a healthy glow over the whole body. Exercise should immediately follow all baths. Warm baths at night should be taken just before retiring; at other hours they should be followed immediately by rest, under coverings, after which exercise should be taken.

2.—Soap is admirably adapted to the removal of dirt from the skin, but if it is too freely used on the general surface of the body, it dissolves the oily exudation of the sebaceous glands, leaving the skin dry or wrinkled. The external epithelial cells may be removed too rapidly when soap is used in excess, consequently the skin is not properly protected.

533. Pure Air is an agent of great importance in the functions of the skin. It imparts to this membrane some oxygen, and receives from it carbonic acid gas. It likewise removes perspiration and portions of the oily secretion.

534. Light exercises a very salutary influence upon the skin. It is no less essential to the vigor of animal than of vegetable life. Dwelling-houses should be built with reference to the free admission of sunlight and air into all occupied rooms. The dark, damp rooms so much used by indigent families and domestics in cities and large villages are fruitful causes of vice, poverty and suffering. Ladies often suffer seriously from too much exclusion of sunlight. Excepting in very warm weather, they should practice sitting or exercising in the full sunshine of the out-door world.

ANALYTIC EXAMINATION.

What are classed under Organs of Special Sense?

Chapter XII.—The Organs of Special Sense.

§ **48.** *Anatomy of the Organs of Special Sense.*—464. What is the organ of the sense of Taste? Give a description of the Tongue. From what nerves are filaments received? 465. Describe the organ of the sense of Smell. Mention the nerves. 466. What is the Eye? Name its parts. Of what service is the Sclerotica? Describe the Choroidea. What is said of the Iris? Of what do the ciliary processes consist? What is the Retina? 467. Describe the Aqueous Humor. Crystalline lens. Observation. 468. What is the Vitreous Humor? Distinguish between it and Aqueous Humor. 469. Speak of the muscles of the Eye. Observation. 470. What are the Orbits? Eyebrows? Eyelids? Observation. Of what does the Lachrymal Apparatus consist? Where is the Lachrymal Gland situated? Describe the Lachrymal Canals. Nasal Duct. 471. What is said of the sense of Hearing? 472. Why the Labyrinth so called? Give its divisions. 473. Describe the Vestibule. 474. Describe the Semicircular Canals. What is contained in the Vestibule and canals? 475. Speak of the Cochlea. 476. What is the Tympanum? Why called the Drum? Where is the Eustachian Tube? What are found in the tympanic cavity? 477. Describe the External Ear. 478. What is the seat of the sense of Touch? What is said of the Skin? 479. Of what does the skin consist? 480. Of what does the Epidermis consist? Give the relation of the Epidermis to the Dermis. What change does the Epidermis experience? What is the seat of color? 481. What is the Cuticle? 482. What is said of the Dermis? 483. Describe the Papillary layer. 484. Speak of the blood-vessels, lymphatics and nerves of the Dermis. 485. Describe the Hair-Follicles. Describe the different parts of a hair. 486. Describe the Oil-Glands. 487. Where are the Sweat-Glands? What are "pores"? What is "insensible transpiration"? 488. Speak of the Nails. Of what is the horny part composed? How do they grow?

§ **49.** *Physiology of the Organs of Special Sense.*—489. State the primary use of the sense of Taste. What is said of this sense in man? What is the effect of cultivation? Observation. 490. Is the sense of Smell one of great importance? Why not? Observation. 491. When light passes through different media, to what changes are its rays subject? What effect have convex or concave surfaces? Illustration. 492. Give the shape of those parts of the eye which act as media. State the use of so many lenses. Illustration. 493. How is the eye able to change the convexity of its lenses and vary its focal distances? Observation. 494. What is the function of the Sclerotic coat? What that of the pigment of the Choroid coat? Illustration. 495. Speak of the accessory parts of the eye. 496. What is Hearing? 497. What is the function of the External Ear? 498. What that of the Auditory Canal? State the design of the Eustachian Tube. Give the uses of the Vestibule, Cochlea and Semicircular Canals. 499. What are distinguished by this sense? How does this apparatus compare with that of vision? 500. Speak of the special organ of the sense of Touch. Observation. 501. State the threefold functions of the skin. 502. Give the uses of the Epidermis. Observation. 503. Where does vitality reside? Why there? 504. What power does the surface of the skin possess? 505. What are the uses of the oil derived from the oil-glands? 506. State the uses of Perspiration. By what is the quantity influenced? 507. What is the influence of the condition of the atmosphere. Observation. 508. Give the functions of the Hair and Nails.

§ **50.** *Hygiene of the Organs of Special Sense.*—509. What perverts the sense of Taste? Observation. 510. By what may the sense of Smell become impaired? 511. What care is necessary in using the eye? 512. What is said in regard to sudden transitions of light? 513. What should be avoided? Observation. 514. How should the eye of the child be trained? Observations. 515. Can the sense of Hearing be improved? 516. How may this sense be impaired? Observation. 517. What parts are absolutely essential, and what not? 518. To what must attention be given to maintain a healthy action of the

skin? 519. What is said of the use of clothing? 520. Of what material should it be Observation. 521. Why should the clothing be porous and loosely fitted? Observation 522. To what must it be suited? Observation. 523. Who require the more clothing? Observation. 524. What is said of clothing when a vital organ is diseased? 525. What persons need less clothing? 526. What is said of cleanliness of the clothing? 527. What of damp clothing? 528. What is indispensable to health? 529. What effect has bathing on the internal organs? 530. Upon what must depend the frequency of bathing? 531. What should the time be? 532. In what diseases is bathing of great importance? Observations. 533. State the influence of pure air. 534. What influence does light exercise?

Fig. 180.

Fig. 180. A Representation of the Brain, Spinal Cord and Spinal Nerves.—1, The cerebrum. 2, The cerebellum. 3, 3, Spinal cord. 4, The sciatic nerve.

A. Distribution of the Olfactory Nerve.—1, 2, Nerve of smell.

B. Optic Nerve.—15, The nerve of vision.

C. The Gustatory Nerve.—1, 2, 3, 4, Branches of the nerve of taste.

D. Auditory Nerve.—13, Nerve of hearing.

SYNTHETIC TOPICAL REVIEW.

Organs of Taste, Smell and Sight,
Sclerotica, Choroidea,
Iris,
Ciliary Processes,
Retina,
Aqueous, Crystalline and Vitreous Humors,
Muscles of the Eye,
Orbits, Eyebrows, Eyelids,
Lachrymal Glands and Canals,
Nasal Duct,
Organs of Hearing,
Labyrinth, Vestibule,
Semicircular Canals,
Cochlea, Tympanum,
External Ear,
Organ of Touch,
Two layers of skin—Epidermis and Dermis,
Hairs,
Sebaceous and Perspiratory Glands,
Nails.

§ 48. *Anatomy of.*

Sense of Taste, Primary use,
" Smell, "
Laws of Light,
" Adaptation of the eye,
Short-sightedness, Cause,
Long-sightedness, "
Defect remedied,
Coats, Function,
Accessory parts of the eye,
Hearing,
External Ear, Function,
Auditory Canal, "
Eustachian Tube, "
Cochlea and Semicircular Canals, Function,
Hearing, Function, "
Organ of Touch,
Skin, Function,
Epidermis and Cuticle, Function,
Corium, Vessels,
Oil-Glands, Function,
Perspiration. Use,
" Quantity,
" External condition,
Hair and Nails.

§ 49. *Physiology of.*

Sense of Taste. Perversion,
" Smell, "
Eye, how to be used,
Amaurosis,
Oblique positions, long-continued,
Viewing objects at different distances,
Bathing the eye,
Dust, removal,
Defective Hearing, Cause,
Hearing, parts essential,
Clothing, Material for
Class of persons needing more clothing,
Clothing, Cleanliness,
Bathing. Modes,
" Time,
Water a curative agent,
Bathing, General Rules,
Skin. Air beneficial,
" Effect of light.

§ 50. *Hygiene of.*

CHAP. XII. *The Organs of Special Sense.*

State the Anatomy, the Physiology and the Hygiene of the Organs of Special Sense, the Care of the Sick, of Poisoned Persons and of persons injured in any way.

APPENDIX.

CHAPTER XIII.

CARE OF THE SICK.

§ **1.** In every home, however humble or dignified, woman is usually the Nurse. Nature seems to have endowed her in an especial manner to minister at the couch of disease and suffering. To be a good nurse requires a high type of womanhood; she should have both mental and physical power, blended with integrity and Christian trust.

If "good nursing is half the cure," how important that the daughter be early taught how to prepare drinks and nourishments, to administer medicine, and to perform the varied and important duties of the faithful nurse!

In the first stages of disease, it is always proper treatment to *rest* both body and mind. It is wrong to tempt the appetite of a sick person; the disinclination for food is the warning of Nature that the system cannot well digest it.

The beneficial effects of *bathing* can hardly be over-estimated, but the mode of the bath should be directed by the medical adviser. The best time, however, for bathing is when the patient feels most vigorous and freest from exhaustion. Care is necessary to wipe dry the skin, particularly between the fingers and toes, and also the flexions of the joints. Friction from a brush, moreen mitten or a dry flannel that has been saturated with salted water tends to relieve restlessness in patients. Chafing with the naked hand, making the movements *from* the nerve-centres to the extremities, is peculiarly soothing, particularly if performed by a vigorous and healthy person. Air-baths have a tranquilizing influence.

The physician well knows that his attention to the sick is quite unavailing unless the nurse *obeys* his directions; for a nurse, or immediate relatives or friends of the sick, to put their judgment

in opposition to that of the physician, is not only arrogant, but endangers the patient. The *room* for the sick should be selected where sunlight may enter, and as far from external noise as possible. It is poor economy, not to say unkind, to keep a sick person in a small, ill-arranged bed-room, when a more spacious and airy room is kept for only occasional "callers." All superfluous furniture should be removed from the sick-room.

Quiet should reign in the sick-room. No more persons should enter or remain in it than the welfare of the patient demands. It is the duty of the physician to direct when visitors should be admitted or excluded, and the nurse should enforce the directions. The movements of the attendants should be gentle: no bustling to "clear up the room" at a fixed time; this should be done quietly, and when it will give the least annoyance to the sick. (It may be necessary to use a *damp* cloth in dusting the furniture, also the carpet, especially if the patient has disease of the lungs.) Creaking hinges should be oiled; shutting doors violently and heavy walking avoided. All unnecessary conversation should be deferred. If a colloquy must be carried on, let the tone be so high that the patient, if interested, can thoroughly comprehend it.

The *making of the bed* is often badly conducted. All bunches should be removed, the material of the bed laid even and a thin quilt spread smoothly over a mattress. When convenient, have the head of the bed northerly (123), and so situated, at least, that the sick man may look on something more pleasurable than a table of glasses and phials. A nurse should never manifest impatience in arranging the pillows, but try to adapt them to the comfort of the weary patient.

All utensils employed in the sick-room should be kept clean. Water designed for the patient to drink should not stand long in an open glass or pitcher, but be given fresh from a *spring* or well. A very sick person is fatigued by being raised to receive drinks, hence a bent tube or a cup with a spout should be used.

Both the *apparel and the bed-linen* should be changed more frequently in sickness than in health, and oftener in acute than in chronic diseases. All clothing, whether from the laundry or bureau, should be well dried and warmed by a fire previous to being put on the bed or the patient.

No agent is of more importance to the sick-room than *pure air;* hence, the nurse, with all convenient speed, should remove everything that can emit an unpleasant odor. She should be chary of

keeping ripe fruit or bouquets of flowers any length of time in the sick-chamber. When a disinfectant is needed, procure some at the druggist's. To change quickly and effectively the air of the sick-room, cover the patient's bed with an extra blanket and closely envelop his head and neck, except the mouth and nose; the door and windows can then be safely opened for a short time without detriment. After the windows are closed, retain the extra coverings on the patient until the room is of proper warmth. Unless duly protected, the patient should never feel *currents of air*, although *fresh air* should be constantly admitted into the sick-room. (It is preferable to have pure air introduced from an adjoining apartment.) Few persons realize the *necessity* of fresh air being constantly admitted into an occupied room, whether by the healthy or the sick. The air exhaled from the lungs contains not only carbonic acid gas, but a *vapor* which gives the peculiar odor to the breath (363). All know its stifling character that have opened a close chamber that has been occupied during the night. Disease may be contracted by inhaling this vapor of respiration, as well as by actual contact with contagious matter.

A well-adjusted thermometer is indispensable, as the feelings of the patient or nurse are not to be relied on as a true index of the *temperature* of the room. Regulating the warmth of the patient is one of the many duties of the nurse. There is a "sweating temperature;" when this is exceeded, perspiration will cease if it has been present, or that it will not take place during a high temperature. The patient should no more be allowed to complain of *too much heat*, without an attempt at its reduction, than he should be permitted to remain chilly when the removal is possible.

The nurse should not confine herself to the sick-room longer than six hours at a time. She should exercise daily in the open air, also eat and sleep as regularly as possible. No doubts or fears of the patient's recovery, either by a look or a word, should be communicated by the nurse in the chamber of the sick; this duty devolves upon the physician.

Medicines assist the natural powers of the system to remove disease. They should be given regularly, judiciously and with a cheerful manner, and administered as directed by the physician. Life itself is often at the mercy of the nurse, and depends on the faithful discharge of her duty.

Drinks have a more decided influence upon the system than is generally admitted. They may be acid or alkaline, cold or hot, as

the condition of the patient requires. The nurse should never depart from the quality of the drink, nor even exceed the due or prescribed quantity. Giving "herb-teas" without the sanction of the physician may cause serious evil.

In diseases of a typhoid character, and also in chronic ailments, where prostration from the waste of tissues and diminished generation of animal heat exists after the subsidence of active disease (when solid food cannot be taken), the gradual introduction into the system of the staminal elements of food that is easily digested and assimilated becomes an important matter. The albuminous, saccharine and oleaginous substances of food, together with an increased amount of carbon, is found in the admixture of refined sugar with sweet pure milk and a small amount of pure alcoholic spirits in the form of "milk punch."

Solid food, as masticating beef steak or dry toasted crackers, is often preferable to gruels and other liquid food, especially when it is necessary to excite an action in the salivary and mucous glands. The food of the sick should be prepared in the neatest and most careful manner, and the nurse ought to obey implicitly the physician's directions about diet. When a patient is convalescent, the desire for food is generally strong; great care, firmness and patience is required that the food be prepared suitably and given at the proper time.

We append a few modes of preparing nourishment for the sick.

Crust Coffee.—Take light, sweet bread or crackers, and brown them *thoroughly* as you would coffee berry; when wanted for use, pour over boiling water (the crusts will admit of several replenishings of boiling water); add sugar and cream to suit the condition of the patient.

Gruels.—*Corn* meal requires to be boiled several hours to be suitable nourishment for the sick. The mode of preparing gruel should be suited to the case and directed by the physician. Wheat, or oat-meal, farina and sago, can be prepared in less time, though they must be well cooked. Add salt while cooking.

Egg Gruel.—Take the *yolks* of two eggs, boiled hard, and with a knife reduce them to a fine powder; beat this into a flour gruel made of new milk; salt and spices may be added if the condition of the patient admits.

Beef Tea.—Meat contains principles that may be extracted, some by *cold,* others by *warm,* and others, again, by *boiling,* water; it should be cut very fine, and submitted for three hours each time,

in succession, to half its weight of cold, of warm and of boiling water; the fluids strained from the first and second macerations are to be mixed with that strained from the boiling process, and the mixture should be brought to a boiling heat to cook it—the fat skimmed off; add a few drops of some acid, with salt, for a flavor.

A quicker, though less nutritious, mode of making beef tea, is to cut beef fine, put it in a glass bottle, cork it, place it in a kettle of cold water, then boil the beef from two to three hours; when cooled, strain the liquor and add salt.

§ **2.** The duty of the WATCHER is scarcely less responsible than that of the nurse, and, like the nurse, she should ever be cheerful, kind, firm and attentive in the presence of the patient.

The watcher should be prompt, and reach the house of the sick at an early hour; before entering the sick-room, she should eat a simple, nutritious supper, and also during the night take some plain food. She should be furnished with an extra garment, as a heavy shawl, to wear toward morning, when the system becomes exhausted.

The directions about the sick, especially the administration of medicine, should be *written* for the temporary watcher. Whatever may be wanted during the night should be brought into the sick-chamber or the adjoining room before the family retires to sleep, that the slumbers of the patient be not disturbed by haste or searching for needed articles.

Sperm candles are preferable for the sick-room. Kerosene, in burning, emits a disagreeable odor, often annoying to the patient. All lights ought to be so arranged as not to be reflected in the part of the room where the sick lie.

It is not necessary that watchers make themselves acceptable to the patient by exhausting conversation. If two watchers are needed, it is more imperative that they refrain from talking, and particularly *whispering.*

Most sick persons have special need of nourishment about four or five o'clock in the morning.

The attendant upon the sick should not sit between the patient and the fire, and also should avoid sitting in the current of air that is flowing out of the room.

When taking care of the sick, light-colored clothing should be worn in preference to dark apparel, especially if the disease is of a contagious character. It is always safe for the watcher to

change her apparel worn in the sick-chamber before entering upon her family duties. Disease is often communicated by the clothing.

It can hardly be expected that the farmer who has been laboring hard in the field, or the mechanic who has toiled during the day, is qualified to render all those little attentions that a sick person requires. Hence, would it not be more benevolent and economical to employ and *pay* watchers who are qualified by knowledge and *training* to perform this duty in a faithful manner, while the kindness and sympathy of friends may be *practically* manifested by assisting to defray the expenses of these qualified and useful assistants?

§ **3.** THE TREATMENT OF WOUNDS OR INJURIES.—*Contusions* or *bruises* are generally treated by the injured person or some member of the family. The bruised limb should *rest*, be kept moderately warm, bathed frequently with tepid water and chafed moderately with the naked hand.

INCISED WOUNDS ("cuts").—At first there is free bleeding from the many divided capillaries. If no large vein or artery is severed, the flow of blood will soon cease; press the gaping wound together, and trickle on cold water until the blood and all foreign matter is removed; then apply narrow strips of adhesive plaster.

FIG. 181.

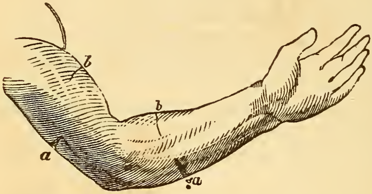


FIG. 181. *a*, *a*, REPRESENTATION OF WOUNDS on the back part of the fore-arm. *b*, *b*, Wounds of the anterior part of the arm and fore-arm. By bending the elbow and wrist, the incisions at *a*, *a*, are opened, while those at *b*, *b*, are closed. Were the arm extended at the elbow and wrist, the wounds at *a*, *a*, would be closed, and those at *b*, *b*, would be opened.

The union of the divided parts is effected by the action of the blood-vessels, and not by "healing salves" or "ointments." The only object of the dressing is to keep the parts together and protect the wound from air and impurities. Nature performs her own cure. Such wounds seldom need a second dressing, and should not be opened till the incisions are healed. To lessen the liability of a reopening, a proper position for the union should be regarded.

If the wound be between the knee and ankle, and on the anterior part, extend the knee and bend up the ankle; if on the posterior part, reverse the movement, and, in general, suit the position to the case.

Fig. 182.

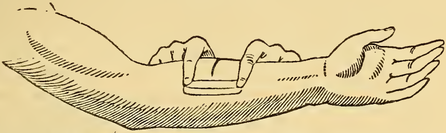


Fig. 182 represents the Manner of applying adhesive strips to wounds.

Lacerated Wounds.—In these injuries, the jagged, torn parts do not heal by the "first intention," but suppurate before cicatrizing. Cleanse the parts with cold water and apply a soft poultice. All wounds made by blunt or pointed instruments, as nails, should be examined by a surgeon.

Wounds from *Poisonous Serpents* or *Rabid Animals* should have cupping-glasses immediately applied, or sucked by the mouth. Give freely alcoholic stimulants until a physician arrives.

Observation.–Although animal poisons, when introduced into the circulating fluid through the broken surface of the skin, frequently cause death, yet they can be taken into the mouth and stomach with impunity, if the mucous membrane which lines these parts is not broken.

Fig. 183.

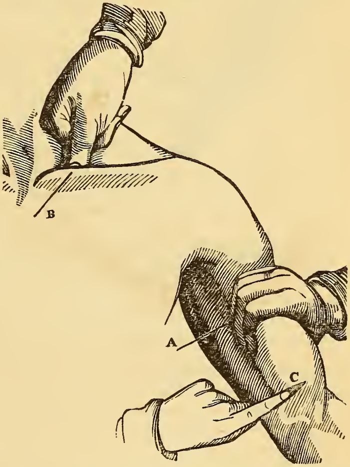


Fig. 183. The Manner of Compressing Divided Arteries.—A, Compressing the large artery of the arm with the thumb. B, The subclavian artery. C, Compressing the divided extremity of an artery *in the wound* with a finger.

Hemorrhage from Divided Arteries should be Arrested, otherwise the heart soon ceases its action, and the person faints. If a large artery is wounded, every beat of the pulse throws out the blood in jerks. Until surgical help can be summoned, the flow of the blood may be stopped either by compressing the vessel between the wound and the heart, or by compressing the end of the artery next the heart in the wound.

Fig. 184.

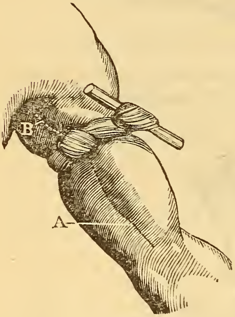


Fig. 185.

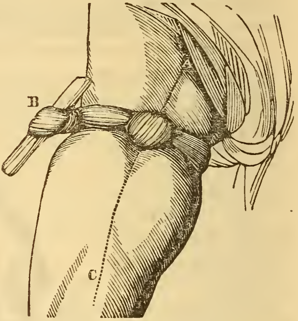


Fig. 184. The Method of Applying the Knotted Handkerchief, to compress a divided artery. A, B, Track of the brachial artery.

Fig. 185. A, C, The track of the femoral artery; the compress applied near the groin.

After compression as described and illustrated, take a square piece of cloth, or handkerchief, twist it cornerwise, and tie a hard knot in the middle. Place the knot over the artery between the wound and the heart, carry the ends around the limb and tie loosely. Place a stick under the handkerchief near the last tie, and twist till the fingers can be removed from the compression without a return of the bleeding. When an artery in a limb be cut, elevate the limb as far as possible, till the bleeding ceases.

Burns and Scalds.—When blisters are formed, the epidermis is separated from the other layer of the skin by the effusion of serum; this fluid should be let free by puncturing the cuticle, care being taken not to remove the thin raised skin, as it makes the best possible protection to the sensitive, inflamed tissues beneath. When this thin outside layer of skin is removed, immediately cover the denuded parts with wheat flour, or a plaster made of lard

and bees'-wax or the white of an egg; in a word, substitute a cuticle to protect the exposed nerves from the air. When dressings are applied, they should not be removed until they become dry and irritating.

To prevent vesication, when only a small patch of the skin is scalded or burned, apply *steadily* cold water until the smarting pain ceases; then put on a simple dressing, "not to take out the fire or to heal it," but to protect the injured membrane.

When the epidermis, in particular spots, is exposed to excessive pressure or friction, it becomes too much thickened, producing "*Corns.*" These are not necessarily confined to the feet, but are produced in front of the clavicle of the soldier from the pressure of his musket, or on the knee of the cobbler. The pain of the callosity is due to its exciting inflammation in the sensitive dermis upon which it presses. Remove the pressure, and the affected part is restored to its normal state.

FROST-BITE is usually manifested first upon parts unprotected by covering, as the face or ears, and especially the nose. In such case, the skin first becomes red, from congestion of the dilated capillary vessels; next it becomes bluish, from arrest of the circulation; and afterward of a dead white hue. To restore circulation and sensibility, rub the frozen part with snow or apply iced water. Keep the sufferer at first in a cold room, and let the return to a higher temperature be *gradual* and cautious, or *gangrene* may supervene.

The CHILBLAIN is not produced by the action of cold, but by the effect of heat on the chilled extremity. Bathe the inflamed parts with a mixture of sweet oil, glycerine and camphorated spirits.

§ 4. *Asphyxia from Drowning, Chloroform or Gas.*

"DROWNING.—1st, Treat the patient *instantly on the spot, in the open air*, freely exposing the face, neck and chest to the breeze, except in severe weather. 2d, In order to *clear the throat*, place the patient gently on the face, with one wrist under the forehead, that all fluid, and the tongue itself, may fall forward and leave the entrance into the trachea or windpipe free. 3d, To excite respiration or *breathing*, turn the patient slightly on his side and apply some irritating or stimulating agent to the nostrils, as hartshorn or dilute ammonia, cologne, etc. 4th, Make the face warm by brisk friction; then dash cold water upon it. If not successful, lose no time to *imitate respiration*.

"Artificial Respiration.—First, place the patient on the face and turn the body gently but *completely on the side and slightly beyond;* then again on the face, repeating alternately these movements, deliberately and perseveringly, *fifteen times* only in a minute.

"*Observation* 1.—When the prone or face position is resumed, make a uniform and efficient pressure along the *spinal column* or back-bone, removing the pressure immediately before rotation on the side; continue these measures. (The pressure augments the expiration, and rotation commences inspiration.)

"2.—When the patient lies on the chest, this cavity is compressed by the weight of the body, and *expiration* takes place; when turned on the side, this pressure is removed, and *inspiration* occurs.

"3.—Rub the limbs *upward*, with *firm pressure* and with energy, to aid the return of venous blood to the heart.

"4.—Rub the body briskly till it is dry and warm, then dash *cold* water upon it and repeat the rubbing.

"Avoid the immediate removal of the patient, as it involves a *dangerous loss of time.* Avoid the warm bath. Substitute for the patient's wet clothing, if possible, such other covering as can be *instantly* procured, each bystander supplying a coat until flannel blankets are obtained. To excite inspiration, let the surface of the body be *slapped briskly* from time to time with the hand."

(*From Marshall Hall's Treatment of Asphyxia from Drowning, Chloroform or Gas.*)

POISONS AND THEIR ANTIDOTES.

§ **5.** Poisoning, either from accident or design, is of such frequency that every household should keep some available remedy, and every person should know *what to do* in such alarming contingencies. Nearly every poison has its antidote, which, *if used at once*, may prevent much suffering and even death.

When known that poison has been taken into the stomach, the first thing is to evacuate it by the use of the stomach-pump or an emetic, unless vomiting takes place spontaneously.

As an emetic, ground *Mustard* mixed in warm water is always safe. Take one tablespoonful to one pint of warm water. Give the patient one-half in the first instance, and the remainder in fifteen minutes, if vomiting has not commenced. In the interval, drink copious draughts of warm water. Irritate the throat with a feather or the finger, to induce vomiting. After vomiting has begun, give mucilaginous drinks, such as flaxseed tea, gum-arabic water, or slippery elm.

If the patient is drowsy, give a strong infusion of cold coffee, keep him walking, slap smartly on the back, use electricity; it may be well to dash cold water on the head, to keep the patient awake. After the poison is evacuated from the stomach, to sustain vital action give warm water and wine or brandy. If the limbs are cold, apply warmth and friction.

In ALL cases of poisoning call immediately a physician, as the after-treatment is of great importance.

Poisons.	Antidotes or Remedies for Poisons.
Aconite (Monkshood). Belladona (Deadly Night-Shade). Bryony. Camphor. Conium, Cicuta (Water Hemlock). Croton Oil. Digitalis (Foxglove). Dulcamara (Bitter-Sweet). Gamboge. Hyoscyamus (Henbane). Laudanum. Lobelia. Morphine. Opium. Paregoric. Sanguinaria (Blood-Root). Savin Oil. Spigelia (Carolina Pink). Stramonium (Thorn Apple). Strychnine (Nux Vomica). Tobacco.	For *Vegetable* poisons give an emetic of *Mustard;* drink freely of warm water; irritate the throat with a feather to induce vomiting. Keep the patient awake until a physician arrive.
Arnica.	*Vinegar* and water.
Prussic Acid. Bitter Almonds (Oil of). Laurel Water.	Drink, at once, one teaspoonful of *Water of Hartshorn* (ammonia) in one pint of water.
Ammonia (Hartshorn). Potash. Soda.	Antidote is *Vinegar* or *Lemon Juice,* followed with sweet, castor or linseed oil. Thick cream is a substitute for oil. No emetic.

Poisons.	Antidotes or Remedies for Poisons.
Iodine.	Starch or wheat flour beat in water. Take a Mustard emetic.
Saltpetre (Nitrate of Potassa). Chili Saltpetre (Nitrate of Soda).	Take, at once, a *Mustard* emetic; drink copious draughts of warm water, followed with oil or cream.
Lunar Caustic (Nitrate of Silver).	Two teaspoonfuls of table salt (chloride of sodium) mixed in one pint of water.
Corrosive Sublimate (bug poison). White Precipitate. Red Precipitate. Vermilion.	Beat the *Whites of six Eggs* in one quart of cold water; give a cupful every two minutes, to induce vomiting. A substitute for white of eggs is *soap-suds* slightly thickened with wheat flour. Emetics should not be given.
Arsenic. Cobalt (fly powder). King's Yellow. Ratsbane. Scheele's Green.	Use a *stomach-pump* as quickly as possible, or give a Mustard emetic until one is obtained. After free vomiting, give large quantities of *Calcined Magnesia.* The antidote for Arsenic is *Hydrated Peroxide of Iron.*
Acetate of Lead (Sugar of Lead). White Lead. Litharge.	Use a *Mustard* emetic, followed by Epsom or Glauber Salts. The antidote is diluted *Sulphuric Acid.*
Antimony (Wine of). Tartar Emetic.	The antidote is ground *Nutgall.* A substitute, oak or Peruvian bark, followed by a teaspoonful of paregoric.
Pearl-ash. Ley (from wood-ashes). Salts of Tartar.	Drink freely of *Vinegar* and water, followed with a mucilage, as flaxseed tea.
Sulphuric Acid (Oil of Vitriol). Nitric " (Aquafortis). Muriatic " (Marine). Oxalic Acid.	Drink largely of water or a mucilage. It is important that something *be given quickly,* to neutralize the acid. The antidote is *Calcined Magnesia.* Chalk, lime, strong soap-suds, are substitutes for magnesia.

Poisons.	Antidotes or Remedies for Poisons.
Matches (Phosphorus). Rat Exterminator.	Give two tablespoonfuls of *Calcined Magnesia*, followed by mucilaginous drinks.
Verdigris. Blue Vitriol.	The antidote is *Cooking Soda*, or *White of Eggs*. Drink milk freely.
Sting of Insects.	*Ammonia*, or cooking soda moistened with water, applied in the form of a paste. The wound may be sucked, followed by applications of water.
Tainted Crabs, Oysters or Fish.	Use a Mustard emetic, and drink freely of vinegar and water.
Charcoal Fumes. Gas or Burning Fluid.	*Fresh* air and Artificial Respiration.

APPENDIX.

Chapter XIII.—Care of the Sick.

§ **1.** *The Nurse.*—What is proper treatment in the first stages of disease? State some of the duties of the nurse in the sick-room—Location of the room—Quiet—Arrangement of the bed—Ventilation of the sick-room—Temperature—Food and drinks. Name the means of nourishment, and tell how they may be prepared.

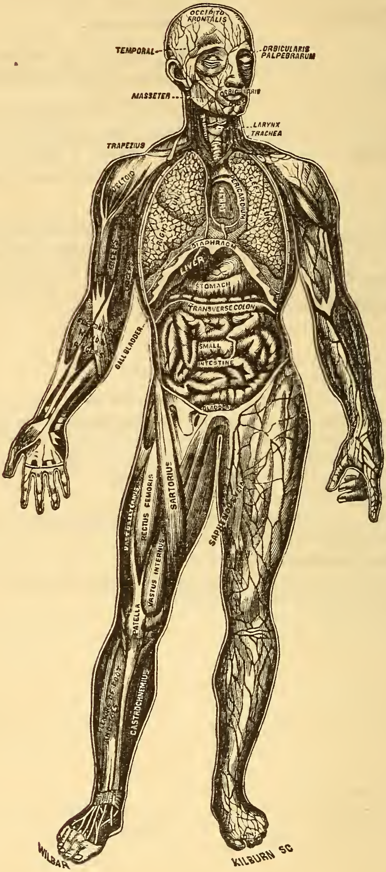
§ **2.** *The Watcher.*—Give the duties of the Watcher.

§ **3.** Give the manner of dressing wounds. How can hemorrhage be arrested? Speak of Burns, Scalds and Frost-Bite, and their treatment.

§ **4.** How may asphyxiated persons be recovered?

§ **5.** *Poisons and their Antidotes.*—When poisons have been taken, what is to be done? Name the most common poisons, and their antidotes.

Fig. 186.


OCCIPITO FRONTALIS
TEMPORAL
ORBICULARIS PALPEBRARUM
MASSETER
LARYNX
TRACHEA
TRAPEZIUS
DELTOID
PERICARDIUM
LIVER
STOMACH
TRANSVERSE COLON
SMALL INTESTINE
GALL BLADDER
SARTORIUS
RECTUS FEMORIS
VASTUS INTERNUS
PATELLA
WILBAR
KILBURN SC

SUMMARY.—SYNTHETIC TOPICAL REVIEW.

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" 1, 2. Care of the Sick. " 3. Treatment of Wounds, Hemorrhage and Burns. " 4. Asphyxia. " 5. Poisons and Antidotes.	CHAP. XIII. *Appendix.*		

State succinctly the Anatomy, the Histology, the Chemistry, the Physiology and the Hygiene of Mammals.

GLOSSARY.

AB-DO′MEN. [L. *abdo*, to hide.] That part of the body which lies between the thorax and the bottom of the pelvis.

AB-SORP′TION. [L. *ab*, and *sorbeo*, to suck up.] The imbibition of a fluid by an animal membrane or tissue.

A-CE-TAB′U-LUM. [L. *acetum*, vinegar.] The socket for the head of the thigh-bone; an ancient vessel for holding vinegar.

A-CE′TIC. [L. *acetum*, vinegar.] Relating to acetic acid. This is always composed of oxygen, hydrogen and carbon in the same proportion.

A-CHIL′LIS. A term applied to the tendon of the two large muscles of the leg.

A-CRO′MI-ON. [Gr. ακρος, *akros*, highest, and ωμος, *ōmos*, shoulder.] A process of the scapula that joins to the clavicle.

AL-BU′MEN. [L. *albus*, white.] An animal substance of the same nature as the white of an egg.

A-LU′MIN-UM. [L.] The name given to the metallic base of alumina.

AL′VE-O-LAR. [L. *alveolus*, a socket.] Pertaining to the sockets of the teeth.

AM-MO′NI-A. An alkali. It is composed of three equivalents of hydrogen and one of nitrogen.

AM-PHIB′I-ANS. [Gr. αμφι, *amphi*, both, and βιος, *bios*, life.] A class of animals so formed as to live on land and in water. At one period of their existence they breathe by gills, at another by lungs.

A-NAS′TO-MOSE. [Gr. ανα, *ana*, through, and στομα, *stoma*, mouth.] The communication of arteries and veins with each other.

AN-A-TOM′I-CAL. Relating to the parts of the body when dissected or separated.

A-NAT′O-MY. [Gr. ανα, *ana*, through, and τομη, *tomē*, a cutting.] The description of the structure of animals. The word *anatomy* properly signifies dissection.

AN-GI-OL′O-GY. [Gr. αγγειον, *angeion*, a vessel, and λογος, *logos*, discourse.] A description of the vessels of the body, as the veins and arteries.

AN′GU-LI. [L. *angulus*, a corner.] A term applied to certain muscles on account of their form.

AN-I-MAL′CU-LÆ. [L. *animalcula*, a little animal.] Animals that are only perceptible by means of a microscope.

AN-NU-LO′SA. [L. *annulus*, a ring.] Furnished with rings; articulata.

AN-TE′RI-OR. [L.] Before or in front in place; opposed to posterior.

A-ORT′A. [Gr. αορτη, *aortē;* from αηρ, *aēr*, air, and τηρεω, *tēreō*, to keep.] The great artery that arises from the left ventricle of the heart.

AP-O-NEU-RO′SIS. [Gr. απο, *apo*, from, and νευρον, *neuron*, a nerve.] The membranous expansion of muscles and tendons. The ancients called every white tendon *neuron*, a nerve.

AP-PA-RA′TUS. [L. *apparo*, to prepare.] An assemblage of organs designed to produce certain results.

AP-PEND′IX. [L. *ad* and *pendeo*, to hang from.] Something appended or added.

A′QUE-OUS. [L. *aqua*, water.] Partaking of the nature of water.

A-RACH′NOID. [Gr. αραχνη, *arachnē*, a spider, and ειδος, *eîdos*, form.] Resembling a spider's web; a thin membrane that covers the brain.

AR′BOR. [L.] *Arbor vitæ.* The tree of life. A term applied to a part of the brain.

AR′TE-RY. [Gr. αηρ, *aēr*, air, and τηρεω, *tēreō*, to keep; because the ancients thought that the arteries contained only

air.] A tube through which blood flows *from* the heart.

A-RYT-E'NOID. [Gr. αρυταινα, *arutaina*, a ewer, and ειδος, *eîdos*, form.] The name of a cartilage of the larynx.

AS-PHYX'I-A. [Gr. α, *a*, not, and σφυξις, *sphyxis*, pulse.] Originally, want of pulse; now used for suspended respiration or apparent death.

AS-TRAG'A-LUS. [Gr.] The name of a bone of the foot; one of the tarsal bones.

AUD-IT-O'RI-US. [L. *audio*, to hear.] Pertaining to the organ of hearing.

AU'RI-CLE. [L. *auricula*, the external ear; from *auris*, the ear.] A cavity of the heart; the "deaf ear."

AX-IL'LA. [L.] The armpit.

A-ZOTE'. [Gr. α, *a*, not, and ζωη, *zōē*, life.] Nitrogen. One of the constituent elements of the atmosphere, so named because it will not sustain life.

BEN-ZO'IC. *Benzoic acid.* A peculiar vegetable acid obtained from benzoin and some other balsams.

BI'CEPS. [L. *bis*, twice, and *caput*, a head.] A name applied to muscles with two heads at one extremity.

BI-CUS'PIDS. [L. *bis*, two, and *cuspis*, a point.] Teeth that have two points upon their crown.

BILE. [L. *bilis*.] A viscid, bitter fluid secreted by the liver.

BI-PEN'NI-FORM. [L. *bis*, two, and *penna*, a feather.] Having fibres on each side of a common tendon.

BRACH'I-AL. [L. *brachium*.] Belonging to the arm.

BRONCH'I-A, -Æ. [L.] A division of the trachea that passes to the lungs.

BRONCH-I'TIS. [L.] An inflammation of the bronchia.

BUR'SÆ MU-CO'SÆ. [L. *bursa*, a purse, and *mucosa*, viscous.] Small sacs containing a viscid fluid, situated about the joints, under tendons.

CÆ'CUM. [L.] Blind; the name given to the commencement of the colon.

CAL'CI-UM. [L.] The metallic basis of lime.

CAL'CIS. [L.] The heel-bone.

CAN-A-LIC'U-LI. [L.] A little pipe or channel.

CAP'IL-LA-RY. [L. *capillus*, a hair.] Resembling a hair; a small tube.

CAP'SULE. [L. *capsula*, a little chest.] A membranous bag enclosing a part.

CA'PUT. [L.] The head. *Caput coli*, the head of the colon.

CAR'BON. [L. *carbo*, a coal.] Pure charcoal. An elementary combustible substance.

CAR-BON'IC. Pertaining to carbon.

CAR'DI-AC. [Gr. καρδια, *kardia*, heart.] Relating to the heart, or upper orifice of the stomach.

CAR'NE-A, -Æ. [L. *caro*, *carnis*, flesh.] Fleshy.

CAR-NIV'O-ROUS. [L. *caro*, flesh, and *voro*, to eat.] Eating or feeding on flesh.

CA-ROT'ID. [Gr. καρος, *karos*, lethargy.] The great arteries of the neck that convey blood to the heart. The ancients supposed drowsiness to be seated in these arteries.

CAR'PUS, -I. [L.] The wrist.

CAR'TI-LAGE. [L. *cartilago*.] Gristle. A smooth, elastic substance, softer than bone.

CAU-CA'SIAN. One of the races of men.

CA'VA. [L.] Hollow. *Vena Cava*, a name given to the two great veins of the body.

CEL'LU-LAR. [L. *cellula*, a little cell.] Composed of cells.

CER-E-BEL'LUM. [L.] The hinder and lower part of the brain, or the little brain.

CER'E-BRO-SPI'NAL. Relating to the brain and spine.

CER'E-BRUM. [L.] The front and large part of the brain. The term is sometimes applied to the whole contents of the cranium.

CER'VI-CAL. [L. *cervix*, the neck.] Relating to the neck.

CHEM'IS-TRY. [Ar. *kimia*, hidden art.] It relates to those operations by which the intimate nature of bodies is changed, or by which they acquire new properties.

CHEST. [Sax.] The thorax; the trunk of the body from the neck to the abdomen.

CHLO'RINE. [Gr. χλωρος, *chlōros*, green.] *Chlorine gas*, so named from its color.

CHOR'DA, -Æ. [L.] A cord; an assemblage of fibres.

CHO'ROID. [Gr. χοριον, *chorion*.] A term applied to several parts of the body that resemble the skin.

CHYLE. [Gr. χυλος, *chulos*, juice.] A nutritive fluid, of a whitish appearance, which

is extracted from food by the action of the digestive organs.

CHYL-I-FI-CA'TION. [L. *chylus*, chyle, and *facio*, to make.] The process by which chyle is formed.

CHYME. [Gr. χυμος, *chumos*, juice.] A kind of grayish pulp formed from the food in the stomach.

CHYM-I-FI-CA'TION. [L. *chumos*, chyme, and *facio*, to make.] The process by which chyme is formed.

CIL'IA-RY. [L. *cilia*, eyelashes.] Belonging to the eyelids.

CIN-E-RI'TIOUS. [L. *cinus*, ashes.] Having the color of ashes.

CLAV'I-CLE. [L. *clavis*, a key.] The collar-bone; so called from its resemblance in shape to an ancient key.

CLEI'DO. A term applied to some muscles that are attached to the clavicle.

CO-AG'U-LUM. [L.] A coagulated mass; a clot of blood.

COC'CYX. [Gr.] An assemblage of bones joined to the sacrum.

COCH'LE-A. [Gr. κοχλω, *kochlō*, to twist; or L. *cochlea*, a screw.] A cavity of the ear resembling in form a snail-shell.

CO'LON. [Gr. κωλον, *kōlon*, I arrest.] A portion of the large intestine.

CO-LUM'NA, -Æ. [L.] A column or pillar.

COM'MIS-SURE. [L. *committo*, I join together.] A point of union between two parts.

COM-PLEX'US. [L. *complector*, to embrace.] The name of a muscle that embraces many attachments.

CON'DYLE. [Gr. κονδυλος, *kondulos*, a knuckle, a protuberance.] A prominence on the end of a bone.

CON-JUNC-TI'VA. [L. *con*, together, and *jungo*, to join.] The membrane that covers the anterior part of the globe of the eye.

COP'PER. A metal of a pale red color tinged with yellow.

COR-A'COID. [Gr. κοραξ, *korax*, a crow, and ειδος, *eîdos*, form.] A process of the scapula shaped like the beak of a crow.

CO'RI-UM. [Gr. χοριον, *chorion*, skin.] The true skin.

CORN'E-A. [L. *cornu*, a horn.] The transparent membrane in the fore part of the eye.

COR'PO-RA. [L. *corpus*, a body.] The name given to eminences or projections found in the brain and some other parts of the body.

COS'TA. [L. *costa*, a coast or side.] A rib.

CRIB'RI-FORM. [L. *cribrum*, a sieve, and *forma*, form.] A plate of the ethmoid bone through which the olfactory nerve passes to the nose.

CRI'COID. [Gr. κρικος, *krikos*, a ring, and ειδος, *eîdos*, form.] A name given to a cartilage of the larynx, from its form.

CRYS'TAL-LINE. [L. *crystallinus*, consisting of crystal.] *Crystalline lens*, one of the humors of the eye.

CU'BI-TUS, -I. [L. *cubitus*, the elbow.] One of the bones of the forearm; also called the *ulna*.

CU'BOID. [Gr. κυβος, *kubos*, a cube, and ειδος, *eîdos*, form.] Having nearly the form of a cube.

CU-NE'I-FORM. [L. *cuneus*, a wedge.] The name of bones in the wrist and foot.

CUS'PID. [L. *cuspis*, a point.] Having one point.

CU-TA'NE-OUS. [L. *cutis*, skin.] Belonging to the skin.

CU'TI-CLE. [L. *cutis*, skin.] The external layer of the skin.

CU'TIS VE'RA. [L. *cutis*, skin, and *vera*, true.] The internal layer of the skin; the true skin.

DE-CUS-SA'TION. [L. *decutio*, I divide.] A union in the shape of an X or cross.

DEL'TOID. [Gr. δελτα, *delta*, the Greek letter Δ, and ειδος, *eîdos*, form.] The name of a muscle that resembles in form the Greek letter Δ.

DEN'TAL. [L. *dens*, tooth.] Pertaining to the teeth.

DE-PRESS'OR. [L.] The name of a muscle that draws down the part to which it is attached.

DERM'OID. [Gr. δερμα, *derma*, the skin, and ειδος, *eîdos*, form.] Resembling skin.

DE-SCEND'ENS. [L. *de* and *scando*, to climb.] Descending, falling.

DI'A-PHRAGM. [Gr. διαφραγμα, *diaphragma*, a partition.] A muscle separating the chest from the abdomen; the midriff.

DI-AR-RHŒ'A. [Gr. διαρρεω, *diarrheō*, to flow through.] A morbidly frequent evacuation of the intestines.

DI-AS'TO-LE. [Gr. διαστελλω, *diastellō*, to put asunder.] The dilatation of the

heart and arteries when the blood enters them.

DI-GES′TION. [L. *digestio.*] The process of dissolving food in the stomach and preparing it for circulation and nourishment.

DOR′SAL. [L. *dorsum*, the back.] Pertaining to the back.

DU-O-DE′NUM. [L. *duodenus*, of twelve fingers' breadth.] The first portion of the small intestine.

DU′RA MA′TER. [L. *durus*, hard, and *mater*, mother.] The outermost membrane of the brain.

DYS′EN-TER-Y. [Gr. δυς, *dūs*, bad, and εντερια, *enteria*, intestines.] A discharge of blood and mucus from the intestines, attended with tenesmus.

DYS-PEP′SI-A. [Gr. δυς, *dūs*, bad, and πεπτω, *peptō*, to digest.] Indigestion or difficulty of digestion.

EN-AM′EL. [Fr.] The smooth, hard substance which covers the crown or visible part of a tooth.

EN-DO-CAR′DI-UM. [Gr. ενδον, *endon*, within, and καρδια, *kardia*, the heart.] The membrane that lines the heart.

EN-DOS-MO′SIS. [Gr. ενδον, *endon*, within, and ωσμος, *ōsmos*, to push.] The transmission of fluids through membranes, inward.

E-PEN′DY-MA. [Gr.] The membrane which lines the ventricles of the brain.

EP-I-DERM′IS. [Gr. επι, *epi*, upon, and δερμα, *derma*, the skin.] The superficial layer of the skin.

EP-I-GLOT′TIS. [Gr. επι, *epi*, upon, and γλωττα, *glōtta*, the tongue.] One of the cartilages of the glottis; during the act of swallowing, it prevents the food entering the larynx.

EP-I-THE′LI-UM. [Gr. επι, *epi*, upon, and θηλη, *thēlē*, a nipple.] A layer of soft cells covering the surface of the lining membranes and part of the skin.

ETH′MOID. [Gr. ηθμος, *ēthmos*, a sieve, and ειδος, *eīdos*, a form.] A bone of the skull.

EU-STA′CHI-AN TUBE. A channel from the fauces to the middle ear; named from Eustachi, who first described it.

EX′CRE-MENT. [L. *excerno*, to separate.] Matter excreted and ejected; alvine discharges.

EX′CRE-TO-RY. A little duct or vessel, destined to receive secreted fluids and to excrete or discharge them; also a secretory vessel.

EX-HA′LANT. [L. *exhalo*, to send forth vapor.] Having the quality of exhaling or evaporating.

EX-TENS′OR. [L.] A name applied to a muscle that serves to extend any part of the body; opposed to *Flexor.*

FA′CIAL. [L. *facies*, face.] Pertaining to the face.

FALX. [L. *falx*, a scythe.] A process of the dura mater shaped like a scythe.

FAS′CI-A. [L. *facia*, a band.] A tendinous expansion or aponeurosis.

FAS-CIC′U-LUS, -LI. [L. *fascis*, a bundle.] A little bundle.

FAUX, -CES. [L.] The top of the throat.

FEM′O-RAL. Pertaining to the femur.

FE′MUR. [L.] The thigh-bone.

FE-NES′TRA, -UM. [L. *fenestra*, a window.] A term applied to some openings into the internal ear.

FI′BRE. [L. *fibra.*] An organic filament or thread which enters into the composition of every animal and vegetable texture.

FI′BRIN. A peculiar organic substance found in animals and vegetables; it is a solid substance, tough, elastic and composed of thready fibres.

FI′BRO-CAR′TI-LAGE. An organic tissue, partaking of the nature of fibrous tissue and that of cartilage.

FIB′U-LA. [L., a clasp.] The outer and lesser bone of the leg.

FIL′A-MENT. [L. *filamenta*, threads.] A fine thread, of which flesh, nerves, skin, etc., are composed.

FLEX′ION. [L. *flectio.*] The act of bending.

FOL′LI-CLE. [L. *folliculus*, a small bag.] A little bag or sac formed of an animal membrane; the orifice is generally minute.

FORE′ARM. The part of the upper extremity between the elbow and hand.

FOS′SA. [L., a ditch.] A cavity in a bone, with a large aperture.

FRÆ′NUM. [L., a bridle.] *Frænum linguæ*, the bridle of the tongue.

FUNC′TION. [L. *fungor*, to perform.] The action of an organ or system of organs.

FUN′GI-FORM. [L. *fungus* and *forma.*

Having terminations like the head of a fungus or a mushroom.

FU-NIC′U-LAR. [L.] Consisting of a small cord.

GAN′GLI-ON, -A. [Gr.] An enlargement in the course of a nerve.

GAS′TRIC. [Gr. γαστηρ, *gastēr*, the stomach.] Belonging to the stomach.

GAS-TROC-NE′MI-US. [Gr. γαστηρ, *gastēr*, the stomach, and κνημη, *knēmē*, the leg.] The name of large muscles of the leg which serve to draw the heel upward.

GEL′A-TIN. [L. *gelo*, to congeal.] A concrete animal substance, transparent and soluble in water.

GING′LY-FORM. [Gr. γιγγλυμος, *ginglumos*, a knife-like joint, and ειδος, *eîdos*, a form.] An articulation that only admits of motion in two directions.

GLAND. An organ consisting of tubes and follicles, with blood-vessels interwoven, from which the gland elaborates its secretion.

GLE′NOID. [Gr. γληνη, *glēnē*, a cavity.] A term applied to some articulate cavities of bones.

GLOS′SA. [Gr.] The tongue. Names compounded with this word are applied to muscles of the tongue.

GLOT′TIS. [Gr.] The narrow opening at the upper part of the larynx.

GLU′TE-US, -I. [Gr.] A name given to muscles of the hip.

GOM-PHO′SIS. [Gr. γομφουν, *gomphoun*, a nail.] The immovable articulation of the teeth with the jaw-bone, like a nail in a board.

GUS-TA′TO-RY. [L. *gusto*, to taste.] A name given to the nerve of taste.

HEM′OR-RHAGE. [Gr. αιμα, *haima*, blood, and ρηγνυω, *rēgnuō*, to burst.] A discharge of blood from an artery or vein.

HERB-IV′O-ROUS. [L. *herba* and *voro*.] Feeding on herbs or vegetables.

HE-PAT′IC. [Gr. ἡπαρ, *hēpar*.] The liver.

HIS-TOL′O-GY. [Gr. ἱστος, *histos*, tissue, and λογος, *logos*, discourse.] A description of the minute structure of the body.

HU′MER-US. [L.] The bone of the arm.

HY′A-LOID. [Gr.] A transparent membrane of the eye.

HY′DRO-GEN. [Gr. ὑδωρ, *hydōr*, water, and γενναω, *gennaō*, to generate.] A gas which constitutes one of the elements of water.

HY′GI-ENE. [Gr. ὑγιεινον, *hugieînon*, health.] The part of medicine which treats of the preservation of health.

HY′OID. [Gr. υ and ειδος, *eîdos*, shape.] A bone of the tongue resembling the Greek letter Upsilon in shape.

HY′PO-GLOS′SAL. Under the tongue. The name of a nerve of the tongue.

IL′E-UM. [Gr. ειλω, *eilō*, to wind.] A portion of the small intestines.

IL′I-UM. The haunch-bone.

IN-CI′SOR. [L. *incido*, to cut.] A front tooth that cuts or divides.

IN′DEX. [L. *indico*, to show.] The forefinger; the pointing finger.

IN-NOM-I-NA′TA. [L. *in*, not, and *nomen*, name.] Parts which have no proper name.

IN-OS′CU-LATE. [L. *in*, and *osculatus*, from *osculor*, to kiss.] To unite, as two vessels at their extremities.

IN-TER-COST′AL. [L. *inter*, between, and *costa*, a rib.] Between the ribs.

IN-TER-STI′TIAL. [L. *inter*, between, and *sto*, to stand.] Pertaining to or containing interstices.

IN-TER-VERT′E-BRAL. [L.] Between the vertebra.

IN-TES′TINES. [L. *intus*, within.] The canal that extends from the right orifice of the stomach to the anus; about thirty feet long.

I′RIS. [L., the rainbow.] The colored circle that surrounds the pupil of the eye.

I′VO-RY. A hard, solid, fine-grained substance of a fine white color; the tusk of an elephant.

JE-JU′NUM. [L., empty.] A portion of the small intestine.

JU′GU-LAR. [L. *jugulum*, the neck.] Relating to the throat; the great veins of the neck.

KER′A-TIN. [Gr. κερας, *keras*, horn.] The albuminous ingredient of the hair and nails.

LA′BI-I. [L.] The lips.

LAB′Y-RINTH. [Gr.] The internal ear, so named from its many windings.

LACH′RY-MAL. [L. *lachryma*, a tear.] Pertaining to tears.

LAC′TE-AL. [L. *lac*, milk.] A small tube of animal bodies for conveying chyle from the intestine to the thoracic duct.

LA-CU′NÆ. [L.] A small pit or depression.

LAM′I-NA, -Æ. [L.] A plate or thin coat lying over another.

LAR′YNX. [Gr. λαρυγξ, *larunx.*] The upper part of the windpipe.

LAR-YN-GI′TIS. Inflammation of the larynx.

LA-TIS′SI-MUS, -MI. [L., superlative of *latus*, broad.] A term applied to some muscles.

LE-VA′TOR. [L. *levo*, to raise.] A name applied to a muscle that raises some part.

LIG′A-MENT. [L. *ligo*, to bind.] A strong, compact substance serving to bind one bone to another.

LIM′BOUS. [L.] Edge or border.

LIN′E-A, -Æ. [L.] A line.

LIN′GUA, -Æ. [L.] A tongue.

LI′VER. The largest gland in the system. It is situated below the diaphragm, and secretes the bile.

LOBE. A round projecting part of an organ.

LOB′ULE. A division of a glandular organ communicating with a single duct.

LUM′BAR. [L. *lumbus*, the loins.] Pertaining to the loins.

LYMPH. [L. *lympha*, water.] A colorless fluid in animal bodies, and contained in vessels called lymphatics.

LYM-PHAT′IC. A vessel of animal bodies that contains or conveys lymph.

MAG-NE′SI-UM. The metallic base of magnesia.

MAG′NUS, -NA, -NUM. [L., great.] A term applied to certain muscles.

MA′JOR. [L., greater.] Greater in extent or quantity.

MAM′MALS, -IA. [L.] Include man and all the ordinary quadrupeds.

MAN′GA-NESE. A metal of a whitish gray color.

MAR′GA-RIN. [Gr. μαργαρον, *margaron*, a pearl.] A fatty substance intermediate in consistency between stearin and olein.

MAR′ROW. [Sax.] A soft, oleaginous substance contained in the cavities of bones.

MAS-SE′TER. [Gr. μασσαομαι, *massaomai*, to chew.] The name of a muscle of the face.

MAS′TI-CATE, MAS-TI-CA′TION. [L. *mastico.*] To chew; the act of chewing.

MAS′TOID. [Gr. μαστος, *mastos*, breast, and ειδος, *eîdos*, form.] The name of a process of the temporal bone behind the ear.

MAX-IL′LA. [L.] The jaw-bone.

ME-A′TUS. [L. *meo*, to go.] A passage or channel.

ME-DI-AS-TI′NUM. A membrane that separates the chest into two parts.

ME′DI-UM, -A. [L.] The space or substance through which a body passes to any point.

MED′UL-LA-RY. [L. *medulla*, marrow.] Pertaining to marrow.

ME-DUL′LA OB-LON-GA′TA. Commencement of the spinal cord.

ME-DUL′LA SPI-NA′LIS. The spinal cord.

MEM′BRA-NA. A membrane; a thin, white, flexible skin formed by fibres interwoven like network.

MES′EN-TER-Y. [Gr. μεσος, *mesos*, in the midst, and εντερον, *enteron*, the intestine.] The membrane by which the intestines are attached to the spinal column.

ME-TA-CAR′PUS. [Gr. μετα, *meta*, after or beyond, and καρπος, *karpos*, wrist.] The part of the hand between the wrist and fingers.

ME-TA-TAR′SUS. [Gr. μετα, *meta*, after or beyond, and ταρσος, *tarsos*, the tarsus.] The instep. A term applied to seven bones of the foot.

MID′RIFF. [Sax. *mid* and *hrife*, the belly.] See DIAPHRAGM.

MI′NOR. [L.] Less, smaller. A term applied to several muscles.

MI′TRAL. [L. *mitra*, a mitre.] The name of the valves on the left side of the heart.

MO-DI′O-LUS. [L. *modus*, a measure.] A cone in the cochlea around which the membranes wind.

MO′LAR. [L. *mola*, a mill.] The name of some of the large teeth.

MOL′LIS. [L.] Soft.

MO′TOR, -ES. [L. *moveo*, to move.] A mover. A term applied to certain nerves.

MU′COUS. Pertaining to mucus.

MU′CUS. A viscid fluid secreted by the mucous membrane.

MUS′CLE. A bundle of fibres enclosed in a sheath.

MY-O-LEM′MA. [Gr. μυς, *mus*, a muscle, and

λεμμα, *lemma*, to receive.] The investing membrane of a fibre.

My-ol′o-gy. [Gr. μυς, *mus*, a muscle, and λογος, *logos*, a discourse.] A description of the muscles.

Na′sal. Relating to the nose.

Nerve. An organ of sensation and motion in animals.

Nerv′ous Cen′tre. A collection of gray nervous matter, which receives impressions and originates the nervous impulses.

Neu-ri-lem′a. [Gr. νευρον, *neuron*, a nerve, and λεμμα, *lemma*, a sheath.] The sheath or covering of a nerve.

Neu-rol′o-gy. [Gr. νευρον, *neuron*, a nerve, and λογος, *logos*, a discourse.] A description of the nerves of the body.

Ni′tro-gen. That element of the air which is called azote.

Nu′cle-us. [L. *nux*, a nut.] The central part of any body, or that about which matter is collected.

Nu-tri′tion. The art or process of promoting the growth or repairing the waste of the system.

Oc′ci-put. [L. *ob*, and *caput*, the head.] The hinder part of the head.

Oc′u-lus, -i. [L.] The eye.

Œ-soph′a-gus. [Gr. οιω, *oiō*, to carry, and φαγω, *phagō*, to eat.] The name of the passage through which the food passes from the mouth to the stomach.

O-lec′ra-non. [Gr. ωλενε, *ōlene*, the cubit, and κρανον, *kranon*, the head.] The elbow; the head of the ulna.

O′le-in. An oily substance which is fluid at ordinary temperatures.

Ol-fact′o-ry. [L. *oleo*, to smell, and *facio*, to make.] Pertaining to smelling.

O-men′tum. [L.] The caul.

O′mo. [Gr. ωμος, *ōmos*, the shoulder.] The name of muscles attached to the shoulder.

Oph-thal′mic. [Gr. οφθαλμος, *ophthalmos*, the eye.] Belonging to the eye.

Op′ti-cus, Op′tic. [Gr. οπτομαι, *optomai*, to see.] Relating to the eye.

Or-bic′u-lar. [L. *orbis*, a circle.] Circular.

Or′gan. A part of the system destined to exercise some particular function.

Or′i-gin. Commencement; source.

Os. [L.] A bone; the mouth of anything.

Os′ma-zome. [Gr. οσμη, *osmē*, smell, and ζωμος, *zōmos*, broth.] A principle obtained from animal fibre which gives the peculiar taste to broth.

Os′se-ous. Pertaining to bones.

Os′si-cle. A little bone.

Os′si-fy. [L. *ossa*, bones, and *facio*, to make.] To convert into bone.

Os′te-ine. [Gr. οστεον, *osteon*, a bone.] The albuminous ingredient of the bones.

Os-te-ol′o-gy. [Gr. οστεον, *osteon*, a bone, and λογος, *logos*, a discourse.] The part of anatomy which treats of bones.

O-va′le. [L.] The shape of an egg.

Ox-al′ic. *Oxaliç acid* is the acid of sorrel. It is composed of two equivalents of carbon and three of oxygen.

Ox′y-gen. A permanently elastic fluid, invisible and inodorous. One of the components of atmospheric air.

Pa-la′tum. [L.] The palate; the roof of the mouth.

Pal-pe-bra′rum. [L. *palpebra*, the eyelid.] Of the eyelids.

Pal′mar. [L. *palma*, the palm.] Belonging to the hand.

Pan′cre-as. [Gr. παν, *pan*, all, and κρεας, *kreas*, flesh.] A long gland situated near the stomach (in domestic animals called the "sweet-bread").

Pan-cre-a′tin or stomach. The albuminous ingredient of the pancreas.

Pa-pil′la, -æ. [L.] Small conical prominences.

Pa-ral′y-sis. Abolition of function, whether of intellect, sensation or motion.

Pa-ren′chy-ma. [Gr. παρεγχεω, *parengcheō*, to pour through.] The substance contained between the blood-vessels of an organ.

Pa-ri′e-tal. [L. *paries*, a wall.] A bone of the skull.

Pa-rot′id. [Gr. παρα, *para*, near, and ωτος, *ōtos*, the gen. of ους, *ous*, ear, the ear.] The name of the largest salivary gland.

Pa-tel′a, -æ. [L.] The knee-pan.

Pa-thet′i-cus, -ci. [Gr. παθος, *pathos*, passion.] The name of the fourth pair of nerves.

Pec′to-ral. [L.] Pertaining to the chest.

PE'DIS. [L., gen. of *pes*, the foot.] Of the foot.

PE-DUN'CLE. [L. *pes*, the foot.] A name applied to parts of the brain, from the resemblance to a flower-stalk.

PEL'I-TONGS. A term applied to masses of fat.

PEL'LI-CLE. [L., dim. of *pellus*, the skin.] A thin skin or film.

PEL'VIS. [L.] The basin formed by the large bones at the lower part of the abdomen.

PEN'NI-FORM. [L. *penna*, a feather.] Having the form of a feather or quill.

PEP'SIN. [Gr. πεπτω, *peptō*, to cook.] An ingredient of the gastric juice which acts as a ferment in the digestion of the food.

PER-I-CAR'DI-UM. [Gr. περι, *peri*, around, and καρδια, *kardia*, the heart.] A membrane that encloses the heart.

PER-I-CHON'DRI-UM. [Gr. περι, *peri*, around, and χονδρος, *chondros*, cartilage.] A membrane that invests cartilage.

PER-I-CRA'NI-UM [Gr. περι, *peri*, around, and κρανιον, *kranion*, the cranium.] A membrane that invests the skull.

PER-I-MYS'I-UM. [Gr. περι, *peri*, around, and μυς, *mus*, a muscle.] The investing membrane of a muscle.

PER-I-OS'TE-UM. [Gr. περι, *peri*, around, and οστεον, *osteon*, a bone.] A membrane that immediately invests the bones of animals.

PER-I-STAL'TIC. [Gr. περιστελλω, *peristellō*, to involve.] A movement like the crawling of a worm.

PER-I-TO-NE'UM. [Gr. περι, *peri*, around, and τεινειν, *teinein*, to stretch.] A thin, serous membrane investing the internal surface of the abdomen.

PER'MA-NENT. Durable; lasting.

PER-SPI-RA'TION. [L. *per*, through, and *spiro*, to breathe.] The excretion from the skin.

PHAL'ANX, -GES. [Gr. φαλαγξ, *phalanx*, an army.] Three rows of small bones forming the fingers or toes.

PHAR'YNX. [Gr. φαρυγξ, *pharunx*.] The upper part of the œsophagus.

PHOS'PHO-RUS. [Gr. φως, *phōs*, the light, and φερω, *pherō*, to bear.] A combustible substance, of a yellowish color, semi-transparent, resembling wax.

PHREN'IC. [Gr. φρην, *phrēn*, the mind.] Belonging to the diaphragm.

PHYS-I-OL'O-GY. [Gr. φυσις, *phusis*, nature, and λογος, *logos*, a discourse.] The science of the functions of the organs of animals and plants.

PI'A MA'TER. [L., good mother.] The name of one of the membranes of the brain.

PIN'NA. [L., a wing.] A part of the external ear.

PLA-TYS'MA. [Gr. πλατυς, *platūs*, broad.] A muscle of the neck.

PLEU'RA, -Æ. [Gr. πλευρα, *pleura*, the side.] A thin membrane that covers the inside of the thorax, and also forms the exterior coat of the lungs.

PLEX'US. [L. *plecto*, to weave together.] Any union of nerves, vessels or fibres, in the form of network.

PNEU-MO-GAS'TRIC. [Gr. πνευμων, *pneumōn*, the lungs, and γαστηρ, *gastēr*, the stomach.] Belonging to both the stomach and lungs.

PNEU-MO-NOL'O-GY. [Gr. πνευμων, *pneumōn*, the lungs, and λογος, *logos*, a discourse.] A description of the lungs.

POL'LI-CIS. [L.] A term applied to muscles attached to the fingers and toes.

PONS. [L.] A bridge. *Pons varolii*, a transverse band of nervous fibres passing in a curved form from one side of the cerebellum to the other, spanning the medulla oblongata.

POS'TI-CUS. [L.] Behind; posterior. A term applied to certain muscles.

POR'TI-O DU'RA. [L., hard portion.] The facial nerve; eighth pair.

POR'TI-O MOL'LIS. [L., soft portion.] The auditory nerve; seventh pair.

PO-TAS'SI-UM. [L.] The metallic basis of pure potash.

PRO-BOS'CIS. [Gr. προ, *pro*, before, and βοσκω, *boskō*, to feed.] The snout or trunk of an elephant or other animal.

PRO'CESS. A prominence or projection.

PRO-NA'TOR. [L. *pronus*, turned downward.] The muscle of the forearm that moves the palm of the hand downward.

PRO-TO'PLASM. [Gr. πρωτος, *prōtos*, first, and πλασμα, *plasma*, formed.] The formal basis of all living bodies.

PRO-TO-ZO'A. [Gr. πρωτος, *prōtos*, first, and ζωη, *zōē*, life.] The infusoria or lowest class of animals.

PUL-MON'IC, PUL'MO-NA-RY, PUL-MO-NA'LIS. [L. *pulmo*, the lungs.] Belonging or relating to the lungs.

PU'PIL. A little aperture in the centre of the iris, through which the rays of light pass to the retina.

PY-LO'RUS. [Gr. πυλωρος, *pulōros*, a gatekeeper.] The lower orifice of the stomach, with which the duodenum connects.

RA'DI-US. The name of one of the bones of the forearm.

RA-DI-A'TA. [L. *radio*, to shoot rays.] Includes those animals whose parts are arranged round an axis and on one or several radii.

RA'DI-ATE. Having lines or fibres that diverge from a point.

REC-RE-MEN-TI'TIAL. [L. *re*, again, and *cerno*, to secrete.] Consisting of superfluous matter separated from that which is valuable.

REC'TUM. [L.] Straight. The third and last portion of the intestines.

RE'FLEX AC'TION. An involuntary action of the nervous system, by which an external impression, conducted by a sensory nerve, is reflected or converted into a motor impulse.

REG'I-MEN. [L. *rego*, to govern.] The systematic regulation of the food and drink.

REP'TILES, -IA. [L. *repo*, to creep.] A class of animals that breathe air from birth and are generally covered with scales.

RE-SID'U-UM. [L.] Waste matter. The fæces.

RES-PI-RA'TION. [L. *re*, again, and *spiro*, to breathe.] The act of breathing; inspiring air into the lungs and expelling it again.

RE-SPI'RA-TO-RY. Pertaining to respiration; serving for respiration.

RET'IN-A. [L. *rete*, a net.] The essential organ of sight. One of the coats of the eye, formed by the expansion of the optic nerve.

RO-DEN'TI-A. [L. *rodo*, to gnaw.] A class of mammals having two large cutting teeth in each jaw, separated from the molar teeth by an empty space.

RO-TUN'DUM, -A. [L.] Round; circular.

RU'GA, -Æ. [L.] A wrinkle; a fold.

RU'MI-NANT. [L.] An animal that chews the cud.

SA'CRUM. [L., sacred.] The bone which forms the posterior part of the pelvis, and is a continuation of the spinal column.

SA-LI'VA. [L.] The fluid which is secreted by glands and poured into the mouth. It is a solvent of the food.

SAN'GUIN-E-OUS. [L. *sanguis*, the blood.] Abounding with blood; plethoric.

SAR-TO'RI-US. [L. *sartor*, a tailor.] A term applied to a muscle of the thigh.

SCA'LA, -Æ. [L., a ladder.] Cavities of the cochlea.

SCA-LE'NUS. [Gr. σκαληνος, *skalēnos*, unequal.] A term applied to some muscles of the neck.

SCAPH'OID. [Gr. σκαφη, *skaphē*, a little boat.] The name applied to one of the wrist-bones.

SCAP'U-LA. [L.] The shoulder-blade.

SCI-AT'IC. [Gr.] Pertaining to the loins. The name of the large nerve of the loins and leg.

SCLE-ROT'IC. [Gr. σκληρος, *sklēros*, hard.] A membrane of the eye.

SE-BA'CEOUS. [L. *sebum*, tallow.] Pertaining to fat; unctuous matter.

SE-CRE'TION. The act of producing from the blood substances different from the blood itself, as bile, saliva; the matter secreted, as mucus, bile, etc.

SE-CRE'TO-RY. Performing the office of secretion.

SE-CUN'DUS. Second. A term applied to certain muscles.

SEM-I-CIR'CU-LAR. Having the form of a half circle. The name of a part of the ear.

SEM-I-LU'NAR VALVES. [L. *semi*, half, and *luna*, the moon.] Name of the three festooned valves of the heart, at the entrance of the great arteries.

SEP'TUM, -A. [L.] A membrane that divides two cavities from each other.

SE'ROUS. Thin; watery. Pertaining to serum.

SE'RUM. [L.] The thin, transparent part of blood.

SER-RA'TED. [L. *serra*, a saw.] Notched on the edge like a saw.

SIG'MOID. [Gr.] Resembling the Greek ς, Sigma.

SI-LI′CI-UM. A term applied to one of the earths.

SI′NUS. [L., a bay.] A cavity, the interior of which is more expanded than the entrance.

SKEL′E-TON. [Gr. σκελλω, *skellō*, to dry.] The aggregate of the hard parts of the body; the bones.

SO′DI-UM. The metallic base of soda.

SPHE′NOID. [Gr. σφην, *sphēn*, a wedge, and ειδος, *eîdos*, likeness.] A bone at the base of the skull.

SPHINC′TER. [Gr. σφιγγω, *sphingō*, to restrict.] A muscle that contracts or shuts an orifice.

SPI′NAL CORD. A prolongation of the brain.

SPINE. A thorn. The vertebral column; back-bone.

SPLANCH-NOL′O-GY. [Gr. σπλαγχνον, *splanchnon*, the bowels, and λογος, *logos*, a discourse.] A description of the internal parts of the body.

SPLEEN. A very vascular organ situated in the abdomen and attached to the stomach; the milt.

SQUA′MOSE. [L.] Scaly.

STA′PES. The name of one of the small bones of the ear.

STE′AR-IN. [Gr. στεαρ, *stear*, suet.] One of the proximate principles of animal fat, which is *solid* at ordinary temperatures.

STER′NUM. The breast-bone.

STIG′MA-TA. The apertures in the bodies of insects communicating with the air-vessels.

STOM′ACH. The principal organ of the digestive apparatus.

STRA′TUM. [L. *sterno*, to spread.] A bed; a layer.

STY′LOID. [L. *stylus*, a pencil.] An epithet applied to processes that resemble a style; a pen.

SUB-CLA′VI-AN. [L. *sub*, under, and *clavis*, a key.] Situated under the clavicle.

SUB-CU-TA′NE-OUS. [L. *sub*, under, and *cutis*, skin.] Situated under the skin.

SUB-LIN′GUAL. [L. *sub*, under, and *lingua*, the tongue.] Situated under the tongue.

SUB-MAX′IL-LA-RY. [L. *sub*, under, and *maxilla*, the jaw-bone.] Located under the jaw.

SUL′PHUR. A simple mineral substance, of a yellow color, brittle, insoluble in water, but fusible by heat.

SU-PI-NA′TOR. [L.] A muscle that turns the palm of the hand upward.

SU′TURE. [L. *suo*, to sew.] The seam or joint that unites the bones of the skull.

SYN-O′VI-A. [Gr. συν, *sūn*, with, and ωον, *ōon*, an egg.] The fluid secreted into the cavities or joints for the purpose of lubricating them.

SYS′TEM. An assemblage of organs composed of the same tissues and intended for the same functions.

SYS-TEM′IC. Belonging to the general system.

SYS′TO-LE. [Gr. συστελλω, *sūstellō*, to contract.] The contraction of the heart and arteries for expelling the blood and carrying on the circulation.

TAR′SUS. [L.] The posterior part of the foot.

TEM′PO-RAL. [L. *tempus*, time.] Pertaining to the temples; so called, because the hair early begins to turn white with age in that portion of the scalp.

TEN′DON. [Gr. τεινω, *teinō*, to stretch.] A fibrous cord by which a muscle is attached to a bone.

TEN-TAC′U-LA, -Æ. [L. *tento*, to seize.] A filiform process or organ on the bodies of various animals.

TEN-TO′RI-UM. [L. *tendo*, to stretch.] A process of the dura mater which lies between the cerebrum and cerebellum.

THO′RAX. [Gr.] That part of the skeleton that composes the bones of the chest; the cavity of the chest.

THO-RAC′IC. Relating to the chest.

THY′ROID. [Gr. θυρεος, *thureos*, a shield.] Resembling a shield. A cartilage of the larynx.

TIB′I′A. [L., a flute.] The large bone of the leg.

TIS′SUE. The texture or organization of parts.

TON′SIL. [L.] A glandular body in the throat or fauces.

TRA′CHE-A. [Gr. τραχυς, *trachus*, rough.] The windpipe.

TRANS-VERSE′. Lying in a cross direction.

TRI′CEPS. [L. *tres*, three, and *caput*, head.] Three. A name given to muscles that have three attachments at one extremity.

TRI-CUS′PID. [L. *tres*, three, and *cuspis*,

point.] The triangular valves in the right side of the heart.

Trit'u-rat-ing. Grinding to a powder.

Troch'le-a. [Gr. τροχαλια, *trochalia*, a pulley.] A pulley-like cartilage, over which the tendon of a muscle of the eye passes.

Troch'le-a-ris. [Gr. τροχαλια, *trochalia*, a pulley.] A muscle of the eye, the tendon of which passes through a pulley-like ring.

Trunk. The principal part of the body, to which the limbs are articulated.

Tu'ber-cle. [L. *tuber*, a bunch.] A pimple, swelling or tumor on animal bodies.

Tu'bule. [L.] A little tube or pipe.

Tur'bi-na-ted. [L. *turbo*, a whirling.] Three rolled or convoluted plates of bone attached to the outer wall of each nostril.

Tym'pan-um. [L.] The middle ear.

Ul'na. [It.] A bone of the fore-arm.

U-re'ter. [Gr. ουρειν, *ourein*, to conduct water.] The excretory duct of the kidneys.

U'ric. [Gr. ουρον, *ouron*, urine.] An acid contained in urine and in gouty concretions.

U-ve'a. [L. *uva*, a grape.] Resembling grapes. A thin membrane of the eye.

U'vu-la. A soft body suspended from the palate, near the aperture of the nostrils, over the glottis.

Vac'cine Vi'rus. [L. *vacca*, a cow; *virus*, poison.] Pertaining to cows; derived from cows.

Valve. Any membrane, or doubling of any membrane, which prevents fluids from flowing back in the vessels and canals of the animal body.

Vas'cu-lar. [L. *vasculum*, a vessel.] Pertaining to vessels; abounding in vessels.

Veins. Vessels that convey blood *to* the heart.

Ven'tri-cle. [L. *venter*, the stomach.] A small cavity of the animal body.

Ver-mic'u-lar. [L. *vermiculus*, a little worm.] Resembling the motions of a worm.

Verm-i-form'is. [L. *vermis*, a worm, and *forma*, form.] Having the form and shape of a worm.

Vert'e-bra, -æ. [L. *verto*, to turn.] A joint of the spinal column.

Ves'i-cle. [L. *vesica*, a bladder.] A little bladder.

Ves'ti-bule. [L.] A porch of a house. A cavity belonging to the ear.

Vil'li. [L. *villus*, hair.] The thread-like projections from the inner surface of the membrane that lines the small intestines.

Vi'rus. [L., poison.] Foul matter of an ulcer; poison.

Vi'tal. [L. *vita*, life.] Pertaining to life.

Vit're-ous. [L. *vitrum*, glass.] Belonging to glass. A humor of the eye.

Vo'lar. [L. *vola*, the hollow of the hand or foot.] Belonging to the palm of the hand.

Vo'mer. [L., a ploughshare.] One of the bones of the nose.

Zyg-o-mat'i-cus. [Gr. ζυγος, *zugos*, a yoke.] A term applied to some muscles of the face, from their attachment.

INDEX.

KEY TO ANATOMICAL OUTLINE PLATES.

SUGGESTIONS TO TEACHERS.

In using these plates, we would suggest that the pupil carefully examine the illustrating cuts interspersed with the text, in connection with the lesson to be recited. The similarity between these and the plates will enable the pupil to recite, and the teacher to conduct his recitation from the latter.

Let a pupil show the situation of an organ, or part, on an anatomical outline plate, and also give its structure, while other members of the class note all omissions and misstatements. Another pupil may give the use of that organ, and, if necessary, others may give an extended explanation. The third may explain the laws on which the health of the part depends, while other members of the class may supply what has been omitted. After thus presenting the subject in the form of topics, questions may be proposed promiscuously from each paragraph, and where examples occur in the text let other analogous ones be given.

If the physiology and hygiene of a given subject have not been studied, confine the recitation to those parts only on which the pupil is prepared. When practicable, the three departments should be united; but this can only be done when the chapter on the hygiene has been learned, while the physiology can be united with the anatomy in all chapters upon physiology.

PLATE I.

A FRONT VIEW OF THE SKELETON.

Bones of the Head.—7, The sphenoid bone. 8, The frontal bone. 10, The parietal bone. 11, The os unguis. 12, The superior maxillary bone (upper jaw). 13, The nasal bone. 14, The ethmoid bone. 15, The malar bone (cheek-bone). 16, The vomer. 17, The inferior maxillary bone (the lower jaw). *a*, Its body. *b*, Its ramus or branch. 18, The teeth.

Bones of the Trunk.—1, 1, The spinal column. 2, The sternum. 3, 3, The ribs. 4, The sacrum. 5, The innominatum.

Bones of the Upper Extremities.—19, The clavicle (collar-bone). 20, The scapula (shoulder-blade). 21, The humerus. 22, The ulna. 23, The radius. 24, 25, 26, 27, 28, 29, 30, 31, The bones of the carpus (wrist). 32, 32, 32, The five bones of the metacarpus (the palm of the hand). 33, 33, 33, The first

range of finger-bones. 34, 34, The second range of finger-bones. 35, 35, 35, The third range of finger-bones.

Bones of the Lower Extremities.—36, The femur (thigh-bone). 37, The patella (knee-pan). 38, The tibia (shin-bone). 39, The fibula. 40, 40, 40, The bones of the tarsus (instep). 41, 41, The bones of the metatarsus (middle of the foot). 42, 42, The bones of the toes.

ARTICULATIONS. (Left side of the plate.)

Ligaments of the Trunk.—1, 1, The common spinal ligament. 2, 2, The intervertebral ligament (cartilage between the vertebræ). 9, 10, 11, 12, Articulations of the ribs with the spinal column. 13, 13, 14, 15, 16, Ligaments that connect the cartilages of the ribs with the sternum.

Ligaments of the Upper Extremities.—25, The ligament that connects the clavicle and sternum. 27, The ligament that connects the upper rib and clavicle. 28, 29, 30, Ligaments that connect the clavicle and scapula. 31, 32, 33, 34, Ligaments of the shoulder-joint. 35, 35, 36, Ligaments of the elbow-joint. 37, 38, 39, 40, Ligaments of the wrist. 41, 42, 43, 44, Ligaments of the fingers.

Ligaments of the Lower Extremities.—49, 49, Ligaments of the hip-joint. 50, 50, Ligaments of the patella. 51, 52, 53, 54, 55, Ligaments of the knee-joint. 56, A large bursa mucosa. 57, The ligament of the tibia and fibula. 58, 58, The interosseous ligament. 59, 59, Ligaments of the ankle-joint. 60, 61, 62, Ligaments of the metatarsus. 63, 64, Ligaments of the toes.

A, The brachial artery. B, The brachial vein. C, The radial artery. D, The femoral artery. E, The femoral vein. F, G, The anterior tibial artery.

PLATE II.

A BACK VIEW OF THE SKELETON.

Bones of the Head.—5, The occipital bone. 6, The parietal bone. 7, The temporal bone. 8, The frontal bone. 9, The sphenoid bone. 15, The malar bone. 16, The nasal bone. 17, The superior maxillary bone (upper jaw). 18, The inferior maxillary bone (lower jaw). 19, The teeth.

Bones of the Trunk.—1, 1, The spinal column. 2, The sacrum. 3, The coccyx. 20, The innominatum. 4, 4, The ribs.

Bones of the Upper Extremities.—21, The clavicle (collar-bone). 22, The scapula (shoulder-blade). 23, The humerus. 24, The ulna. 25, The radius. 26, 27, 28, 29, 30, 31, 32, The bones of the carpus (wrist). 33, 33, 33, The bones of the metacarpus (palm of the hand). 34, 34, 34, The first range of finger-bones. 35, 35, The second range of finger-bones. 36, 36, 36, The third range of finger-bones.

Bones of the Lower Extremities.—37, The femur (thigh-bone). 38, The patella (knee-pan). 39, The tibia (shin-bone). 40, The fibula. 41, 42, 43, 44, 45, The bones of the tarsus (instep). 46, 46, The bones of the metatarsus (middle of the foot). 47, 47, Bones of the toes.

ARTICULATIONS. (Left side of the plate.)

Ligaments of the Trunk.—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, Ligaments of the spinal column. 14, 14, 15, 15, Ligaments that connect the ribs and spinal column. 11, 11, 21, 22, 23, 24, 25, 26, Ligaments that connect the sacrum and innominatum.

Ligaments of the Upper Extremities.—27, 28, Ligaments that connect the clavicle and scapula. 29, The capsular ligament of the shoulder-joint. 30, 30, Ligaments of the elbow. 31, 32, 33, 34, Ligaments of the carpus (wrist).

Ligaments of the Lower Extremities.—9, Tendon of the gluteus muscle. 35, The capsular ligament of the hip-joint. 36, 36, Ligaments of the knee-joint. 37, The ligament that connects the tibia and fibula. 38, The interosseous ligament. 39, 40, Ligaments of the ankle-joint.

PLATE III.

A FRONT VIEW OF THE MUSCLES.

Muscles of the Head and Neck.—7, The sterno-mastoideus muscle. 8, The sterno-hyoideus muscle. 9, The omo-hyoideus muscle. 10, The trapezius muscle. 11, The orbicularis oculi muscle. 12, The frontal muscle. 14, The orbicularis oris muscle. 15, The elevator muscle of the nostrils. 16, The zygomatic muscle. 17, The depressor of the lower lip. 18, The depressor anguli oris muscle. 19, The triangular muscle of the nose. 20, 21, The aural muscles. 22, The masseter muscle.

Muscles of the Trunk.—2, 3, The external oblique muscles.

Muscles of the Upper Extremities.—1, The grand pectoral muscle. 3, 4, The serratus muscle. 23, The deltoid muscle. 24, The biceps brachialis muscle. 25, The coraco-brachialis muscle. 26, The anterior brachial muscle. 27, The triceps brachialis muscle. 28, The long supinator muscle. 29, The external radial muscle. 30, The pronator teres muscle. 31, The anterior radial muscle. 32, The palmaris brevis muscle. 33, The anterior ulnar muscle. 35, The palmar muscle. 36, The abductor muscle of the thumb. 37, The adductor muscle of the thumb. 38, 39, Small flexor muscles of the thumb. 40, The abductor muscle of the little finger. 41, 41, The lumbricales muscles. 61, 61, The bifurcation of the tendons of the superficial flexor muscle, in the fingers.

Muscles of the Lower Extremities.—42, The fascia lata muscle. 43, The sartorius muscle. 44, The rectus femoris muscle. 45, The vastus externus muscle. 46, The vastus internus muscle. 47, The internal straight muscle. 48, The pectineus muscle. 49, The adductor muscle. 50, The psoas muscle. 51, The tibialis anticus muscle. 52, The long extensor muscle of the great toe. 53, The long extensor muscle of the toes. 54, The anterior peroneal muscle. 55, The long lateral peroneal muscle. 56, 57, The gastrocnemii muscles. 58, The long flexor muscle of the great toe. 59, The short extensor muscles of the toes. 60, The abductor muscle of the great toe.

The figures and letters on the left side of the plate indicate the position of important fasciæ that cover the muscles and enclose the tendons.

PLATE IV.

A BACK VIEW OF THE MUSCLES.

Muscles of the Head and Neck.—4, The sterno-mastoideus muscle. 5, The complexus muscle. 6, The mylo-hyoideus muscle. 7, 8, The occipito-frontalis muscle. 9, The masseter muscle. 10, 11, 12, The anterior, middle and posterior aural muscles. 13, The temporal muscle.

Muscles of the Trunk.—1, 1, The trapezius muscle. 2, The latissimus dorsi muscle. 3, The rhomboideus muscle. 4, The external oblique muscle.

Muscles of the Upper Extremities.—5, The deltoid muscle. 6, 7, The infraspinatus muscle. 9, The triceps extensor muscle. 10, The internal brachial muscle. 11, The long supinator muscle. 12, The external radial muscle. 13, The second external radial muscle. 14, The anconeus muscle. 15, 16, The extensor digitorum communis muscle. 17, The extensor carpi ulnaris muscle. 18, The flexor carpi ulnaris. 19, 20, The extensor ossis metacarpi pollicis muscles. 21, An extensor muscle of the thumb. 22, 28, Interossii muscles.

Muscles of the Lower Extremities.—29, The gluteus maximus muscle. 30, The gluteus medius muscle. 31, The biceps flexor cruris muscle. 32, The semi-tendinosus muscle. 33, The semi-membranosis muscle. 34, The gracilis muscle. 35, The adductor muscle. 36, The vastus externus muscle. 37, The sartorius muscle. 38, 39, The gastrocnemii muscles. 40, The long peroneal muscle. 41, The external peroneal muscle. 42, The long flexor muscle of the great toe. 43, The long extensor muscle of the toes. 44, The short extensor muscle of the toes. 47, The short flexor muscle of the toes.

The figures and letters on the left side of the plate indicate the position of membranous fasciæ which envelop the muscles and tendons.

PLATE V.

ORGANS OF THE THORAX AND ABDOMEN.

FIG. 1. *The Mouth and Neck.* (A side view.)—1, The upper lip. 2, The lower lip. 3, The upper jaw. 4, The lower jaw. 5, The tongue. 6, The hard palate (roof of the mouth). 7, The parotid gland. 8, The sublingual gland. T, The larynx. 10, The pharynx. 11, The œsophagus. 12, The upper portion of the spinal column. C, The spinal cord.

The Chest and its Organs.—9, 9, The trachea. R, The right auricle of the heart. L, The left auricle. 13, The left ventricle of the heart. 14, The right ventricle. 15, The aorta. 16, The pulmonary artery. 17, The vena cava descendens. 18, The right subclavian vein. 19, The left subclavian vein. 20, The right jugular vein. 21, The left jugular vein. 22, The right carotid artery. 23, The left carotid artery. 24, 25, 26, The upper, middle and lower lobes of the right lung. 27, 28, The upper and lower lobes of the left lung. 29, 29, 29, The diaphragm. P, P, P, P, The pleura that lines the cavity of

the chest. S, S, The clavicles. O, O, O, O, The ribs. M, M, M, M, Muscles of the chest. 40, The thoracic duct, opening into the left subclavian vein.

The Abdomen and its Organs.—30, The stomach. 31, 32, The right and left lobe of the liver. F, The fissure that separates the two lobes. 33, The gall-bladder. 34, 34, The duodenum. 35, The ascending colon. 36, The transverse colon. 37, The descending colon. 38, 38, 38, 38, The small intestine. 39, 39, The walls of the abdominal cavity turned down. 41, The spleen.

Fig. 2. *The Relation of the Lacteals and Thoracic Duct.*—1, 1, A section of the small intestine. 2, 2, 2, 2, 2, 2, 2, 2, Mesenteric glands, through which the lacteals from the intestine pass. 3, Several lacteal vessels entering the enlarged portion and commencement of the thoracic duct. 5, 5, 5, The thoracic duct. 6, The thoracic duct opening into the left subclavian vein. 7, (See 40, Fig. 1.) 8, The right subclavian vein. 9, The vena cava descendens. 10, 11, 11, The aorta. 12, The carotid arteries. 13, 13, The jugular veins. 14, The vena azagos. 15, 15, The spinal column. 16, The diaphragm.

Fig. 3. *The Relation of the Larynx, Trachea, Bronchia and Air-Cells.*—1, 1, 1, An outline of the right lung. 2, 2, 2, An outline of the left lung. 3, The larynx. 4, The trachea. 5, The right bronchia. 6, The left bronchia. 7, 7, 7, 7, Divisions of the right bronchia. 8, 8, 8, 8, Divisions of the left bronchia. 9, 9, 9, 9, 9, 9, Air-cells.

Fig. 4. *An Ideal View of a Lateral and Vertical Section of the Larynx.*—1, 1, The superior vocal cords (ligaments). 2, 2, The inferior vocal cords. 3, 3, The glottis. 4, 4, The ventricles of the larynx.

PLATE VI.

HEART, ARTERIES AND VEINS.

Fig. 1. *The Heart and Large Arteries.*—1, The right auricle of the heart. 2, The right ventricle of the heart. 3, The left auricle. 4, The left ventricle. 5, The pulmonary artery. 6, The aorta. 7, 7, The descending aorta. 8, The arteria innominata. 9, The left carotid artery. 10, The left subclavian artery. 56, The right subclavian artery.

Arteries of the Neck and Head.—15, The right carotid artery. 16, The left carotid artery. 17, The right temporal artery. 50, The right facial artery. 54, The left temporal artery.

Arteries of the Upper Extremities.—11, 11, The left brachial artery. 12, The left radial artery. 13, 13, The right brachial artery. 14, The right radial artery. 51, The right ulnar artery.

Arteries of the Lower Extremities.—18, The left iliac artery. 19, The right iliac artery. 20, The left femoral artery. 21, The right femoral artery. 22, The peroneal artery. 23, The left anterior tibial artery. 24, The muscular artery. 25, 25, The right and left arteria profunda. 26, The right anterior tibial artery. 27, The right peroneal artery.

The Veins of the Neck and Head.—28, The vena cava descendens. 29, The

left subclavian vein. 30, The right subclavian vein. 31, The right jugular vein. 32, The left jugular vein. 53, The right temporal vein. 55, The left temporal vein. 49, The right facial vein.

Veins of the Upper Extremities.—33, The left brachial vein. 34, The left radial vein. 35, The right brachial vein. 36, The right radial vein. 51, The right ulnar vein.

Veins of the Lower Extremities.—37, The vena cava ascendens. 38, The left iliac vein. 39, The right iliac vein. 40, The left femoral vein. 41, The right femoral vein. 42, The left anterior tibial vein. 43, The left peroneal vein. 44, The right anterior tibial vein. 45, The right peroneal vein. 46, 46, The profunda veins. 47, The muscular veins. 48, 48, 48, 48, 48, 48, Intercostal arteries and veins.

Fig. 2. *The Relation of the Cavities of the Heart to the Large Blood-vessels.*—1, The vena cava descendens. 2, The vena cava ascendens. 3, The right auricle of the heart. 4, The opening between the right auricle and right ventricle. 5, The right ventricle. 6, The tricuspid valves. 7, The pulmonary artery. 8, 8, The branches of the pulmonary artery that pass to the right and left lung. 9, The semilunar valves of the pulmonary artery. 10, The left pulmonary veins. 11, The right pulmonary veins. 12, The left auricle. 13, The opening between the left auricle and left ventricle. 14, The left ventricle. 15, The mitral valves. 16, 16, The aorta. 17, The semilunar valves of the aorta. 18, The septum between the right and left ventricle.

Fig. 3. *An Ideal View of the Heart, Arteries and Veins.*—A, The right auricle. B, The right ventricle. C, The tricuspid valves. D, The opening between the right auricle and right ventricle. E, The left auricle. F, The left ventricle. G, The mitral valves. H, The opening between the left auricle and left ventricle. I, The septum between the right and left ventricle. K, The pulmonary artery. L, The semilunar valves of the pulmonary artery. M, M, The right pulmonary artery. N, N, The left pulmonary artery. O, O, O, O, O, O, The capillary vessels of the lungs. P, P, P, The right pulmonary vein. Q, Q, The left pulmonary vein. R, R, The aorta. S, The semilunar valves of the aorta. T, T, A branch of the aorta to the upper extremities. U, U, U, U, A branch to the lower extremities. V, V, V, V, V, V, The capillary vessels at the extremity of the branches of the aorta. W, W, The descending vena cava. X, X, X, The ascending vena cava.

In Figs. 1, 2, 3, the course of the blood through the circulatory vessels is indicated by arrows.

PLATE VII.

THE PULMONARY CIRCULATION.

Fig. 1.—1, The right auricle of the heart. 2, The left auricle. 3, The right ventricle of the heart. 4, The left ventricle. 5, The pulmonary artery. 6, The branch of the pulmonary artery to the left lung. 7, The branch of the pulmonary artery to the right lung. 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, Branches of the pulmonary artery in the right and left lung. 9, 9, 9, 9, 9, 9, Air-cells. 10,

10, 10, 10, 10, 10, 10, Small pulmonary veins in the right and left lung. 11, The left pulmonary vein. 12, 12, The right pulmonary vein.

FIG. 2. *An Ideal View of the Pulmonary Circulation.*—1, 1, The right lung. 2, 2, The left lung. 3, The trachea. 4, 4, 4, 4, 4, The right bronchia. 5, 5, 5, 5, 5, The left bronchia. 6, 6, 6, 6, 6, 6, Air-cells, with arteries and veins passing around them. 7, The right auricle of the heart. 8, The right ventricle of the heart. 9, The tricuspid valves. 10, The pulmonary artery. 11, 11, 11, 11, The right pulmonary artery. 12, 12, 12, 12, 12, The left pulmonary artery. 13, 13, 13, 13, The right pulmonary vein. 14, 14, 14, 14, The left pulmonary vein. 15, The left auricle. 16, The left ventricle. 17, The mitral valves. 18, The septum between the right and left ventricles.

FIG. 3. *An Ideal View of the Capillaries.*—1, 1, A branch of the pulmonary artery. 2, 2, A branch of the pulmonary vein. 3, 3, Capillary vessels between the artery and vein.

FIG. 4. *An Ideal View of the Relations of the Bronchia, Air-Cells, Pulmonary Arteries and Veins.*—1, A bronchial tube. 2, 2, 2, Air-cells. 3, A branch of the pulmonary artery. 4, A branch of the pulmonary vein.

PLATE VIII.

THE CEREBRUM, CEREBELLUM, SPINAL CORD AND NERVES.

1, The cerebrum. 2, The cerebellum. 3, 3, The spinal cord. 4, The brachial plexus of nerves. 5, The lumbar plexus of nerves. 6, The sacral plexus of nerves. 7, The facial nerve. 8, 17, The radial nerve. 9, 9, 16, The ulnar nerve. 10, The median nerve. G, The circumflex nerve of the shoulder.

11, 11, The great sciatic nerve. 12, The external popliteal or peroneal nerve. 13, 13, The posterior tibial nerve. 14, The external tibial nerve. 15, The muscular branch of the external peroneal nerve. 18, The muscular branch of the sciatic nerve. P, Q, The posterior tibial nerve.

The letters and other figures indicate minor nervous filaments distributed to the various muscles and the skin.

PLATE IX.

THE SKIN.

FIG. 1. *A Perspiratory Tube and Gland.*—1, 1, The contorted portion of the tube that forms the gland. 2, 2, Two branches which unite to form the main duct of the gland. 3, 3, The perspiratory tube. 4, The cuticle. 5, Its colored portion. 6, The cutis vera (true skin). 7, 7, Fat vesicles in which the gland is imbedded.

FIG. 2. *A Papilla of the Skin.*—1, 1, Two papillæ, formed of an artery, vein and nerve. 2, 2, 2, 2, Nerves forming a loop in the papillæ. 3, 3, Arteries of the papillæ. 4, 4, Veins of the papillæ. 5, 5, A network of arteries, veins and nerves. 6, 6, Nerves of the skin. 8, 8, Arteries of the skin. 7, 7, Veins of the skin.

Fig. 3. *A Hair and its Oil-Glands.*—1, 1, The hair. 2, 2, The sheath of the hair. 3, Oil-glands that surround the bulb of the hair, the ducts of which open into the sheath of the hair (2, 2).

Fig. 4. *A Section of the Skin.*—1, 1, The cuticle. 2, 2, Its colored portion. 3, 3, The papillary layer. 4, 4, A network of arteries, veins and nerves upon the upper surface of the cutis vera. 5, 5, 5, 5, The cutis vera (true skin). 6, 6, 6, Hairs that originate in the cutis vera. 7, 7, 7, Oil-glands, the ducts of which connect with the sheath of the hair. 8, 8, 8, 8, 8, 8, 8, 8, Perspiratory glands and their ducts. 9, 9, 9, 9, 9, Nerves of the skin. 10, 10, 10, 10, 10, Arteries of the skin. 11, 11, 11, 11, 11, Veins of the skin. 12, 12, 12, 12, Papillæ, or ridges of the skin.

PLATE X.

AN ANTERO-POSTERIOR SECTION OF THE EYE.

Fig. 1.—1, 1, The sclerotic coat. 2, 2, The cornea. 3, 3, The choroid coat. 4, 4, The retina. 5, 5, The iris. 6, 6, The posterior chamber of the eye that contains the aqueous humor. 7, 7, The anterior chamber. 8, 8, The pupil. 9, The crystalline humor. 10, 10, The vitreous humor. 11, The optic nerve. 12, A representation of a pen. 13, An inverted image of the pen (12) on the retina. 14, 14, A canal surrounding the crystalline humor. 15, 15, The beveled junction of the cornea and sclerotic coat. A, A perpendicular ray of light from the pen. B, B, Oblique rays that are refracted in passing through the humors of the eye.

Fig. 2. *A View of the External, Middle and Internal Ear.*—1, 1, The external ear. 2, The meatus auditorius externus (the tube that connects with the middle ear). 3, The membrana tympani (drum of the ear). 8, 8, The tympanum (middle ear). 4, The malleus. 5, The incus. 6, The orbicularis. 7, The stapes (stirrup-bone) that connects with the vestibule of the internal ear. 9, 9 (4, 5, 6, 7, The small bones of the middle ear), 10, 11, 12, The semicircular canals. 13, 13, The cochlea. 14, The auditory nerve. 15, The division of the auditory nerve to the semicircular canals. 16, The division to the cochlea. 17, 17, The Eustachian tube. 18, The chorda tympani nerve. 19, The seventh pair (facial) nerve. 20, The styloid process of the temporal bone. 21, 21, 21, 21, 21, The petrous or hard portion of the temporal bone, in which the parts of the middle and internal ear are situated.

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